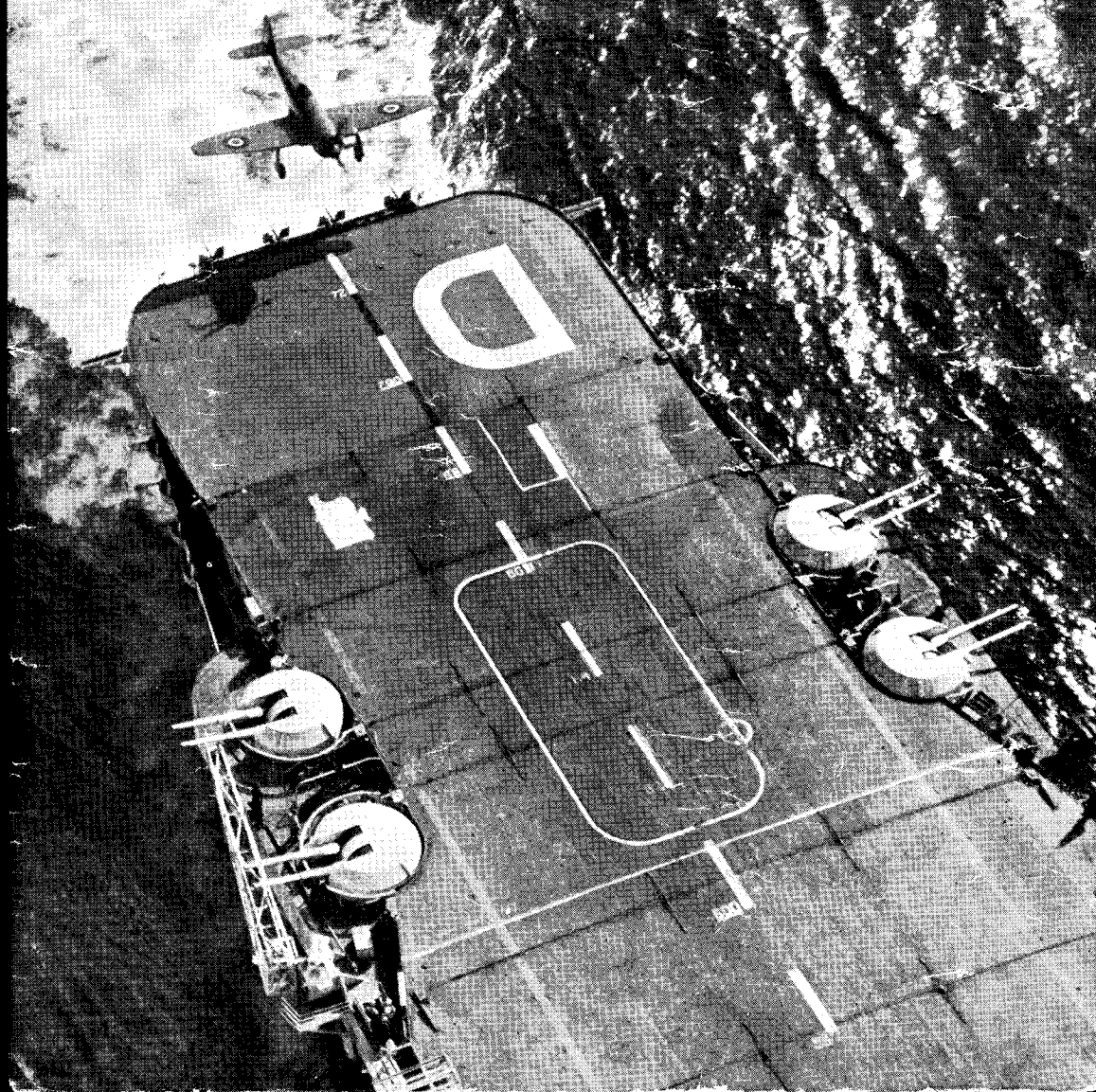


# THE MODEL ENGINEER

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# The MODEL ENGINEER

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## S M O K E R I N G S

### Our Cover Picture

● THIS STRIKING illustration shows a Hawker "Sea Fury" coming in to land on the flight deck of H.M. Aircraft Carrier *Illustrious*. The picture was taken by Mr. Cyril Peckham, official photographer for Hawker Aircraft Limited, from a D.H. "Dominie," during the trials of the Hawker "Sea Fury." Figures of the carrier's crew should be noted.

### A Reader Referendum

● THE LARGE number of appreciative letters we receive, and the fact that our journal sells right out immediately it is published might be taken together as a very definite sign that our contents give general satisfaction to our readers. Our editorial problem is, however, not quite as simple as that. It is complicated by the very limited number of pages allowed by our restricted paper ration and the difficulty of covering adequately within that space all the thousand and one aspects of model engineering and the very varied activities of the home workshop. Our readers are by no means universal in their interests—some like this subject and some that, others dislike this or that or perhaps feel that space might be more acceptably allotted to this subject in preference to that one. Since it is important that we should use our space for the greatest good of the greatest number, we shall

insert in our next issue, on the page backing club announcements, a questionnaire to which we should be glad if as many readers as possible would reply. Its purpose will be obvious, and the replies should prove very helpful both to our readers and ourselves. It will answer some of our occasional critics whose constructive suggestions we are always glad to have, and will be a useful guide to our acceptance or otherwise of articles which though excellent in themselves would be of interest only to a very limited section of our readers. In filling in your replies on the voting paper, please use a soft pencil—our printing paper does not respond kindly to pen and ink.

### The Society of Inventors

● I HAVE been asked to call the attention of my readers to the existence of The Society of Inventors, a voluntary organisation formed especially for the benefit of the small inventor. The Society at present has its head offices in Liverpool, with branches in Manchester, Birmingham and London. My correspondent, Mr. A. H. Maytum, is a model engineer of long standing, and is now Chairman of the Manchester Branch. Full information as to the services offered by the Society, and conditions of membership, may be obtained from the Hon. Secretary, Mr. A. B. Gordon, B.Sc., 99, Old Hall Lane, Fallowfield, Manchester.

### To Faversham Readers

● A PROPOSAL is on foot to found a society for readers in the Faversham and Sittingbourne districts. Support has already been promised, but it is felt that there must be a number of other engineers and ship modellers who would like to co-operate, and they are asked to communicate with Mr. R. W. Partis or A. W. Neal at 14, Edith Road, Faversham.

### He Lost His "M.E."

● A CORRESPONDENT who lives somewhere "up-country" in Australia writes:—"One of my interests is coal mining, and at Muswellbrook we have two ordinary mines and an open cut which produces about 2,000 tons daily. I was down in the cut recently and to my utter amazement saw a copy of THE MODEL ENGINEER in the middle of the road. Apparently it had dropped from someone's pocket. Truly, your little magazine gets into some queer places. Of course, I rescued it, but so far have not located its owner." If the owner cares to write to me I can put him in touch with the finder. Missing copies are hard to replace in Australia.

### A Craftsmanship Exhibition

● THOSE WHO admire good craftsmanship in its many forms will find much of interest in an exhibition to be held at the Guildhall, London, from February 26th to March 20th. The display is organised by the Arts and Crafts Exhibition Society, and will consist largely of professional work, though amateurs are encouraged to exhibit if approved by the selection committee. The range of exhibits will include furniture, pottery, silverwork, jewellery, and bookbinding, all of a very high standard. Further information may be obtained from the Secretary of the Society, 6, Queen Square, W.C.1.

### To Ickenham Readers

● A NOTE from Mr. C. F. Clarabut tells me that there is a prospect of a club being formed for readers in the Ickenham and Ruislip area. The local Community Association has promised the use of a hall for meetings, and there is a possibility of some ground being available for a track. Mr. Clarabut invites communications at 31, Burnham Avenue, Ickenham.

### Perranporth Progress

● I HEAR that the modest little society at Perranporth is becoming well established. The first annual report shows a growing membership and a satisfactory financial position. During the past year several interesting visits have been paid to local engineering works, and arrangements are in hand for a 1948 exhibition at St. Michael's Church Hall from July 21st to the 28th. A new Hon. Secretary has been appointed, Mr. W. J. Baker, Post Office, St. Piran's Road, Perranporth.

### Good Wishes from Glasgow

● I AM grateful to the Glasgow S.M.E. for the following kindly message transmitted by the Hon. Secretary, Mr. John W. Smith. He writes: "I am directed by the Council, at a recent meeting, to express to you and to the excellent paper you were the means of creating, their

very best wishes upon the occasion of your fiftieth year of publication. It has been a task, they feel sure, which received your best, and your reward is surely evident in the nationwide development of the model maker's art and craftsmanship. Although somewhat belated in their wish to express themselves, the Council beg you to accept their best interests, and they trust you may long be spared to guide the enterprise you started." Thank you, Glasgow.

### A Forthcoming Bristol Show

● I HAVE received details of the Annual Model Engineering and Handicraft Show to be held on March 20th in the Bristol Aeroplane Company's Canteen at Filton Works. There is a generous list of prizes, including the Challenge Trophy offered for the most meritorious handicraft exhibit by an adult employee of the Company. The various classes open for competition include model engineering, aeromodelling, woodwork, art, and photography. The organisers would be pleased to receive offers of loan exhibits from any local model makers or handicraft workers, a feature which last year added much to the general interest of the show. Full details may be obtained from Mr. E. F. Ashford, Junior Welfare Organisation, at Filton House, Bristol.

### Instructive Valve-gears

● THE USE of working models of valve-gears for locomotive instruction classes is well known, but a correspondent tells me of a slight modification in these models which has been adopted on a South African railway. In this case the model is so arranged that it will reproduce any defect in valve-setting or adjustment, and a student may then be asked to locate the trouble and provide the remedy. I do not know if any adaptable models of this kind are in use elsewhere, as these instruction models are generally only used to illustrate the working of the gear when everything is in order. It certainly adds to the value of the instruction afforded by such a model.

### The Late Mr. John Cotter

● IT IS with regret that we record the recent passing, at his home in Cork, of Mr. John Cotter, whose workshop and activities were described in our issue of July 18th, 1935. Mr. Cotter was probably one of the more versatile of our readers, for in addition to making many tools and models he was adept at copper repoussé work and woodwork—including carving. His all-round ability is well illustrated by the models he made, which included locomotives, a yacht, a steam tug and a marine engine. His work was especially creditable in view of the fact that his daily task was of a clerical nature and he had not had the benefit of any mechanical training. Always ready to assist others, his kindly and genial nature will be greatly missed by his friends, many of whom had been made through THE MODEL ENGINEER.

*Percival Hannay*

# A Versatile Local Light

by R. Harries

## A lamp stand with a high degree of adjustability

THE need for efficient lighting on the work-bench, machine, drawing-board or office desk is now becoming appreciated, and more attention is being devoted to the design of sound light sources and fittings and their proper distribution. It has been proved that the increased output from operators, and their continued contentment, due respectively to the efficiency and psychological effect of a good lighting system, have more than compensated for the initial extra expense and trouble entailed. General lighting is seldom brilliant enough to enable detailed work to be performed on the bench or machine, and in these cases the above illumination is supplemented by a local light, which is made adjustable so that it can be manoeuvred into any position convenient to the operator.

The present lighting fitting, Fig. 1, is a local light, and it has been designed by the writer to provide the maximum amount of adjustability combined with finger touch control, so enabling the light to be arranged easily and quickly in any position to satisfy the operator. These desirable features have been achieved by employing in the design a system of balanced arms, and avoiding the customary friction washers as generally incor-

porated to provide stiff joints in the linkage system.

Reference to the line drawing, Fig. 2, which gives an isometric view of the lamp extended, and also the photographic illustration, Fig. 1, will enable the reader to understand the construction and principle of operation. The lamp is enclosed in a shade A, which is pivoted on its

balance point between the two arms of a metal U-shaped frame B. Entering through a hole in the back of B, and also through a similar hole in the bridge-piece C, is a metal tube D. A spring ring let into a groove in D, together with the belled-out end of D, prevent the endwise movement of B relative to D, but allow rotation. The far end of D fits tightly through the centre of a cylindrical metal block E. The short length of D, projecting to the right, passes through a circular lead weight G, which is secured by means of the grub-screw entering from the top. The two arms of the narrow U-shaped frame H lie each side of E, and a bolt J passing through enables D to pivot on it, and allows the weight to pass through the gap. Since J also passes through D, any possibility of end movement of the latter relative to E is avoided. H has a bridge-piece riveted across the gap near the bot-

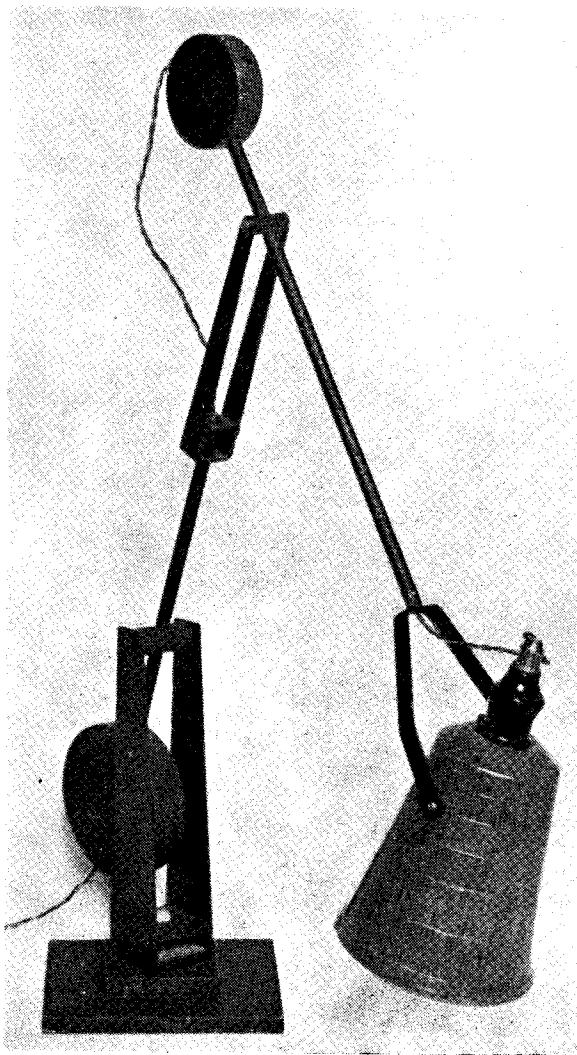
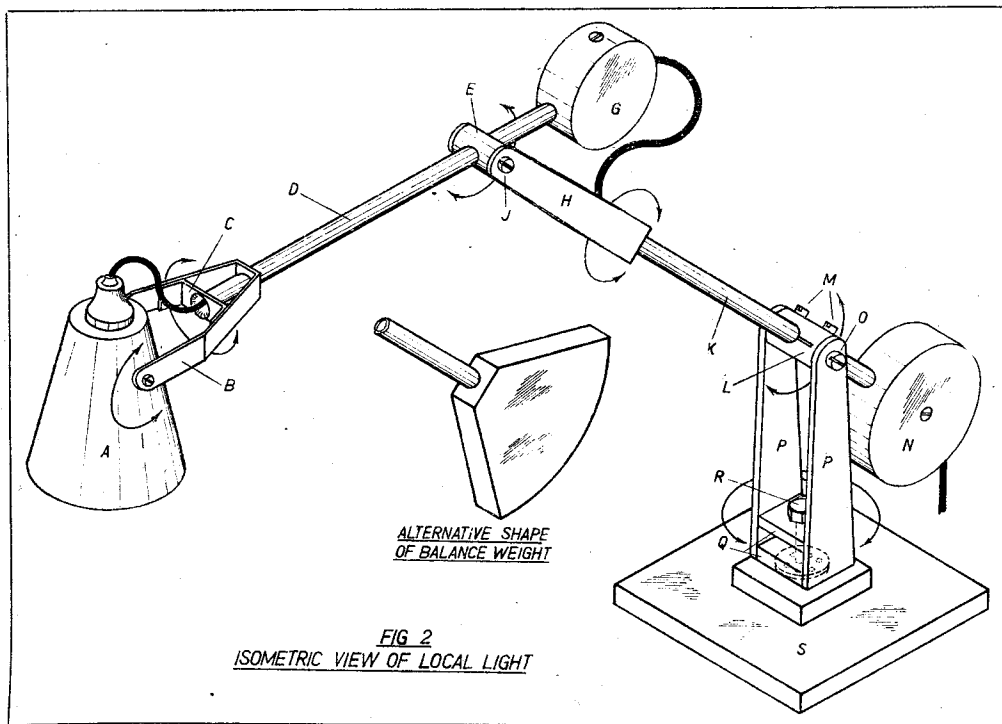


Fig. 1. General view of local light

tom end, and a hole through its centre and another through the bottom of H provide bearings for the tubular arm K. Endwise movement but not rotation of H is prevented by belling out the near end of K and providing a spring ring let into a groove at the back in the same manner as for the frame B.

A crosswise hole through another cylindrical block L receives K, and the latter is securely held by splitting L axially along its central portion to make it springy enough to close on K when drawn together by the two screws M. The continuation of K on the far side, enters a lead counterweight N, to which it is clamped by the side grub-screw as is done for G. L hinges on the two bolts O, which enter from opposite sides of the two uprights P, the latter being spaced apart by means of the two platforms Q, so that N can swing through the gap thus formed. A bolt R, passing down through the centres of Q into a base S, enables the whole appliance to swing around about the base plate.

B. The rotation of B about its axis in its turn does not affect the position of the resultant mentioned above. This force acts at the end of arm D, and the moment thus produced is counterbalanced by a heavier mass G acting at a shorter distance. Thus arm D can swing about independently, and it also has a resultant force acting downwards at the pivotal point J. Frame H, being capable of rotation about K, naturally carries with it arm D and all its attached parts, and this additional sideways motion is achieved without disturbing the equilibrium of the previous forces. This last resultant acts at the end of the arm K, and its moment is counteracted by the weight N acting at a shorter arm. A further rotation of the whole appliance is provided by mounting it on a vertical pivot R. It will be obvious that the lamp could equally well be mounted on a wall bracket or pedestal in preference to the base block illustrated, should it be desired to use it on the bench or at a machine tool. Any or all of the movements mentioned



The bottom plate Q does not rest direct on the base, there being a simple thrust-rod interposed between the two surfaces to reduce friction. Throughout its run, the flex from the lampholder is conveniently tucked away in the tubular arms D and K.

The principle of operation of the lamp is as follows. The lampholder, with attached holder and lamp, is pivoted about its balance point, so for any position of it, the resultant force is constant, and always acts downwards at a point midway between the two pivot screws in the frame

can take place together, without disturbing the original balance of forces, so that practically no friction is required at the pivotal points, and light action is assured, combined with a very wide range of positioning.

In order that the lead counterweights G and N shall be kept as small and light as possible, keep the weight of the fittings at the end of arms D and K as light as strength will allow. A modified shape to the counterweight can also be incorporated if desired, as shown inset Fig. 2, so as to have the effect of bringing the centre

of gravity of their mass farther away from the pivotal point, so increasing the moment and calling for a smaller weight.

As a guide to prospective builders, dimensions of the actual lamp made by the writer to house a 60-watt bulb, are shown in the sub-assembly detail drawing, Fig. 3. To satisfy the requirements of lightness mentioned above, the

first to avoid accidents. As duralumin begins to harden soon after being annealed, carry out the necessary bending immediately after softening. Don't forget to soften the tube ends where they are bell-mouthed, in addition to the strip.

In order to cast the lead weights neatly, procure a piece of wood the same width as the weight is to be. Cut a circular hole in its centre

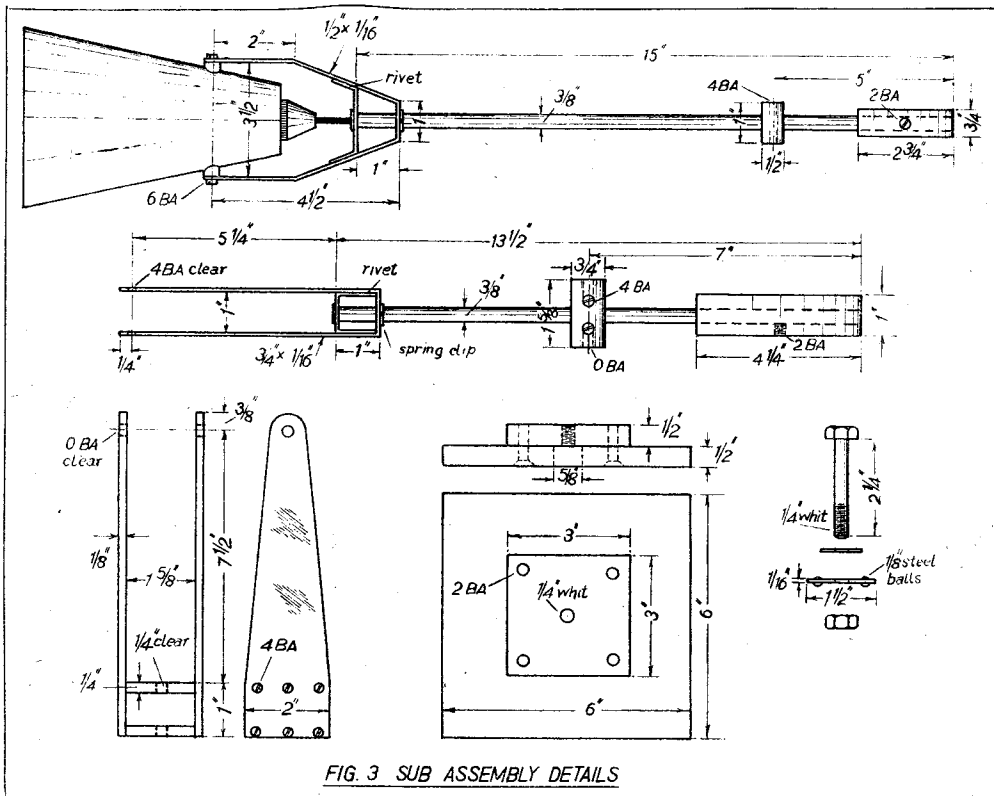


FIG. 3 SUB ASSEMBLY DETAILS

tubular arms D and K, the strip frames B and H, and the cylindrical block E, should be made of duralumin. Also do not use an unnecessarily heavy lampshade—an aluminium one is the best. The rest of the parts can be made from whatever metal is to hand. The base S, in the writer's case, is built up from steel plate, but there is no reason why wood should not be used, as a heavy mass is not needed here for any counterbalancing as in the normal type of table lamp. For those who may not have worked in duralumin, it should be pointed out that, as bought, it is too hard a condition to bend sharply due to an age-hardening process which occurs. Softening can, however, be carried out by annealing it at a temperature between 360 and 400 deg. C., and cooling in air or water. The best way to carry out this annealing process on such a small job is to rub soap on the parts where bending is to occur, and then heat in a gas flame until the soap has charred and turned black. Experiment with a piece of scrap strip

and a slot in one side leading into the hole for pouring purposes. Drill a  $\frac{3}{8}$  in. hole crosswise through the block to pass along a diameter of the large hole and insert into it a  $\frac{3}{8}$ -in. steel rod. Paint some plumber's graphite or similar preparation over the rod to prevent sticking to the molten lead. Enclose the sides of the large hole by clamping a metal plate each side of the wood block. Run the molten lead in through the side slot, and after setting give the  $\frac{3}{8}$ -in. rod a blow to loosen. Dismantle the mould and clean the weight with a coarse file, followed by the drilling and tapping of the side hole for the clamp screw. Other details of construction will be clear from the drawings. The whole assembly can be finished in paint to suit individual colour schemes.

When finally setting up the lamp, first of all adjust weight G to counterbalance the weight at the lamp, end, then adjust weight N to counterbalance the mass at the other end of tube K.

# \*Swords into Ploughshares

Hints on the adaptation of "surplus" war material  
for model engineering or utility purposes

## Notes on Aircraft Instruments

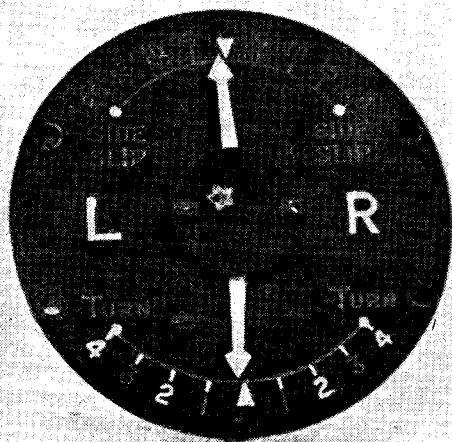
by "Artificer"

THE numerous and varied types of thermometers used on aircraft include simple direct-reading forms, such as the fluid-expansion capillary-column type, and differential metallic-expansion types, similar to the well-known "Rototherm" instruments. But most aircraft thermometers have the dial necessarily a long

much longer column, and in using the pressure due to expansion instead of the height of the column, to record the reading.

The effect of thermal expansion in the capillary tube itself may cause errors in the reading of this type of instrument, if, as commonly happens, it is of great length and subject to a different temperature to that of the element. To correct this, in tubes having a length exceeding 20 ft., a "compensating link" is inserted in the line. This consists of a steel chamber, containing a block of Invar alloy steel (having an almost negligible expansion coefficient), with a narrow space around it for the passage of the mercury. On increase of temperature in the line, when expansion of the mercury would normally increase the pressure and show a high reading on the dial, the difference in expansion between the steel chamber and the Invar block causes the space around the latter to increase, thereby lowering the mercury pressure and correcting the reading. A reduction of temperature in the line, of course, produces a reverse effect.

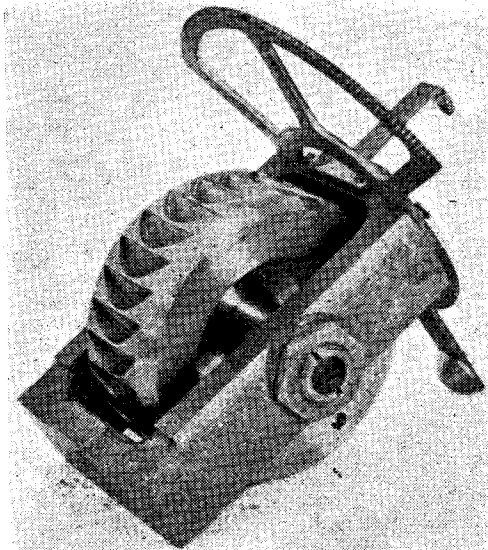
In thermometers of the vapour pressure type,



*Dial of gyroscopic turn and bank indicator*

way removed from the actual heat-receiving element, and are therefore of the "remote reading" or "transmitting" type. These, in turn, may be subdivided into two groups, employing mechanical and electrical principles of operation, respectively.

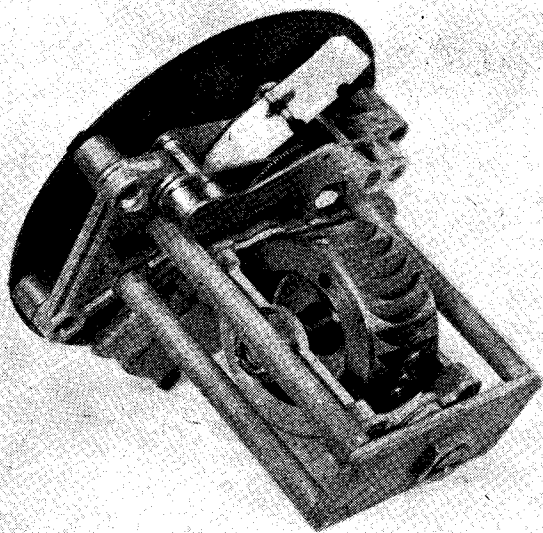
In the former, the readings are in all cases recorded by a dial instrument which is, to all intents and purposes, a form of pressure gauge, usually employing the Bourdon tube movement, but specially calibrated in terms of temperature. The heat-receiving element may be of the "fluid pressure" or "vapour pressure" type, according to the range of temperature to be covered. In the former, mercury is usually employed, and must completely fill the bulb of the element, the Bourdon tube, and the communicating pipe, which is of very small ("capillary") bore; the system is then completely sealed. This form of instrument differs from the direct reading column type only in having a



*The gyroscope and gimbal frame assembly*

the system is not completely filled with liquid; instead, the bulb is about half full of a volatile liquid such as ether, and the pressure is obtained from the expansion of the vapour, rather than that of the liquid itself. Errors due to the

\*Continued from page 127, "M.E.", January 29, 1948.



*Movement of indicator, showing fan brake for damping motion of gimbil frame*

expansion of the capillary tube itself are less than with the fluid expansion type, and do not usually call for the use of a compensating device. Thermometers of this type are generally employed in the liquid cooling systems of aircraft engines, and may be adapted to similar use in the radiators or cooling tanks of any form of water-cooled engines. The bulb should in such cases be located at or near the highest point in the circulating system, to record the maximum temperature reached by the cooling water.

As the Bourdon type of pressure gauge records the difference of pressure between the inside and outside of the tube, it tends to read high when the atmospheric pressure is reduced at high altitudes. On the other hand, the boiling point of water or other liquids, when open to atmosphere, becomes lower as the altitude increases. For open cooling systems, where the temperature of the liquid must be kept below boiling point, the dial of the thermometer is usually marked to show safe temperatures at various altitudes.

#### **Electric Thermometers**

Only a brief description of these instruments can be given here, but it may be possible to return to the subject later, when it is hoped that more detailed information will be available. They embody two distinct principles of operation, one of which is the well-known "thermopile," in which

heat actually produces an electrical effect; the other is not self-generating, but must be energised by means of a battery, and works by virtue of the fact that the resistance of an electrical conductor varies with change of temperature.

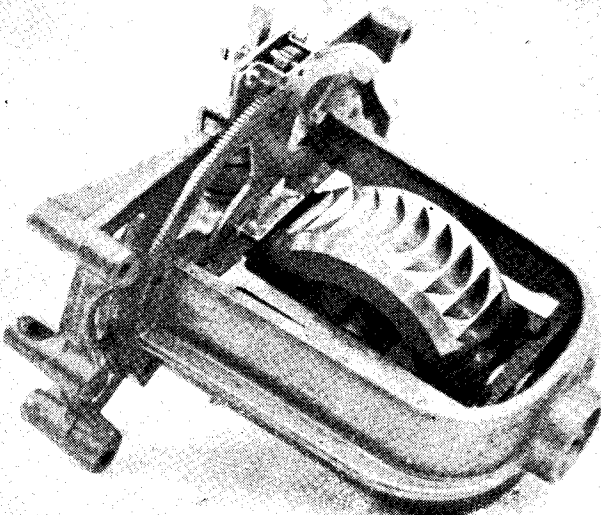
In both cases, the dial movements of these thermometers consist of sensitive electrical measuring instruments, of the moving coil type; but whereas the former employs a simple instrument which may be converted by recalibration, to serve for ordinary electrical measurements, the latter is equipped with a more complex movement, having a compensating coil to cancel out the effect of any possible variation in the voltage of the exciting battery. Instruments of this type are usually known as "ratiometers," as they measure the ratio of the heat-receiving resistance to that of a second "control" resistance, kept at substantially constant temperature.

Electrical thermometers can be calibrated to suit a very wide variety of temperatures, and are equally applicable to readings on either an "open"

or "close" scale, or for extremely low ("sub-zero") or extremely high ("pyrometric") readings. The thermopile type is commonly used to record cylinder and combustion chamber temperatures in aircraft engines, and gas turbine bearing temperatures.

#### **The Gyroscope**

The gyroscopic principle is used in several types of aircraft instruments at the present time, and as many such instruments are now available



*Another type of movement having a die-cast frame and piston damping device*

on the surplus market, readers may be particularly interested in their possibilities. In all the instruments in this class, the primary object is the indication or control of direction, though they vary widely in their details and also their complexity. They include the Turn and Bank Indicator, the Artificial Horizon, the Directional Gyro or Gyro-Compass, and the Automatic ("Robot") Pilot.

The gyroscope, which is the fundamental working part in these instruments, consists of a dynamically balanced flywheel, mounted in delicate anti-friction bearings, and adapted to be driven at very high speed. The means of driving may be either mechanical or electrical; in the former case, the gyro rotor is usually made in the form of a simple impulse turbine, driven by means of an air jet; in the latter, various types of high-speed electric motors are used, generally built into the rotor and gimbal frame of the gyro.

From the point of view of readers of this journal, the mechanical type of gyro is probably the most interesting, particularly as it provides facility for both observation and experiment, not only with the gyroscope, but also with small turbines. The electrically-driven gyros which are employed in the more complex instruments usually employ special synchronous motors which work on high-frequency multi-phase alternating current, and as this cannot be obtained without using a special form of generator or converter, it is almost impossible to run them at all in the home workshop. At least one type of instrument has a direct-current commutator motor, which could be run off a battery of appropriate voltage, but so far as can be ascertained, none of the instruments of this particular type are available on the surplus market. It is proposed therefore to deal only with the mechanically-driven instruments, at least for the present.

The simplest of all the gyroscopic instruments is the Turn and Bank indicator, which, strictly speaking, embodies two distinct but complementary instruments in one; namely, the directional or "turn" indicator, which is worked by the gyroscope, and the "bank" indicator, operated by a simple pendulum or "plumb-bob," which is enclosed in a chamber to provide air damping and thus prevent unsteady movement. Strictly speaking, this movement indicates, not the angle of banking, but side-slip, and is sometimes termed a slip indicator. In normal flight conditions, turning movement is accompanied by banking or tilting movement, much the same as with a bicycle, the angle of bank depending on the rate of turn, so as to counteract centrifugal force and produce the effect of an artificial gravitational pull acting through the normal perpendicular centre line of the aircraft. Under such conditions, the pendulum remains central, but should the angle of bank be either insufficient or excessive to preserve correct balance, side-slipping of the craft will result and the pendulum will swing to one side or the other; this indicates an unstable condition, which calls for correction by the pilot.

In the instrument shown, the pendulum operates the pointer on the upper half of the dial, that on the lower part being operated by the gyroscope.

It is not within the scope of this series of articles to enter into a lengthy dissertation on the principles and properties of the gyroscope. Most readers are, however, at least familiar with this device in its elementary form, though comparatively few people seem to have a very comprehensive knowledge of its working theory. It is, however, a fascinating device, which will well repay close investigation by the engineering student or experimental engineer. Briefly, it may be stated that a rotating gyroscope tends to maintain a position of equilibrium, and to resist any change in the angular plane of its axis; but any force tending to produce such change will cause a reaction or "precession" at right angles to that at which the force is applied.

The gyroscope, to be effective as a balancing or direction indicating device, must be mounted in a frame which is free to rotate in at least one plane, and sometimes two, according to the particular action required. This frame is known as the gimbal frame, and will be seen in the photograph in the form of a rectangular frame, having bearings for the rotor in the side members, and bearings in the ends by means of which the assembly is supported in the housing of the instrument. The latter is located so that the rotor axis lies in the fore and aft plane of the aircraft. So long as the latter moves on a straight course, the equilibrium of the gyro will remain undisturbed, and the gimbal frame will remain horizontal in a cross plane, being normally held in this position by a light tension spring, as shown in Fig. 10. But if the direction of motion of the aircraft changes, the angle of the gyro axis is also forcibly changed, and reacts by tilting the gimbal frame on its axis, to one side or the other, this movement being communicated to the pointer which moves over the lower scale of the instrument dial. The rack quadrant seen in the photograph of the gyro assembly is for the purpose of operating a damping device, to prevent oscillation or flutter of the pointer. In instruments examined, two types of damping mechanism have been observed, one being in the form of a "fly" or fan brake, and the other a small dashpot with a piston operated by a crank on the pinion shaft. Other minor variations of detail, such as alternative constructional methods using castings or fabricated parts, are embodied in different types or "marks" of these instruments, three of which have been examined (there may be more), but in all cases essential principles are the same. The instruments in question were obtained from the Aero Spares Company, of Church Street, Edgware Road, London, N.W., who have large stocks of them in hand at present.

It should be noted that this type of instrument is not a direction indicator in the true sense of the term, but measures the *rate of deviation* from a straight course. That is to say, the pointer moves from the centre of the scale during the turn, to an extent dependent on the turning rate, but returns to zero when the turn is completed and the aircraft is flying straight on its new course.

The gyroscope and gimbal movement cannot therefore be adapted to the directional control of a model, such as a boat or aeroplane, without modification and elaboration of detail. It would

be necessary to provide a second gimbal frame, pivoted at right angles to the first frame and at right angles to the gyro axis; also to provide means of controlling the precession of the latter.

This equipment is provided in instruments such as the Artificial Horizon and the Directional Gyro, but up to the present, the writer has not had an opportunity of examining instruments of

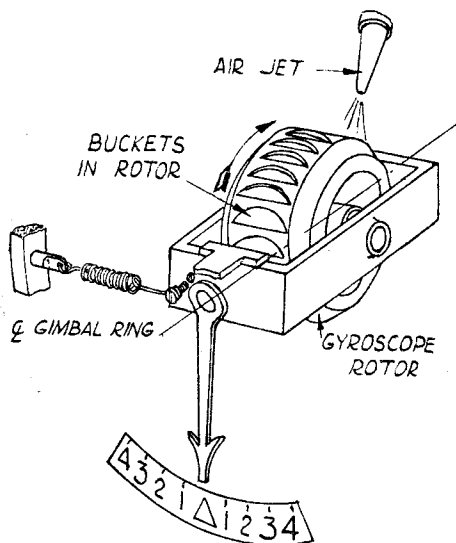


Fig. 10. Diagram illustrating principle of air-driven gyroscope in turn and bank indicator

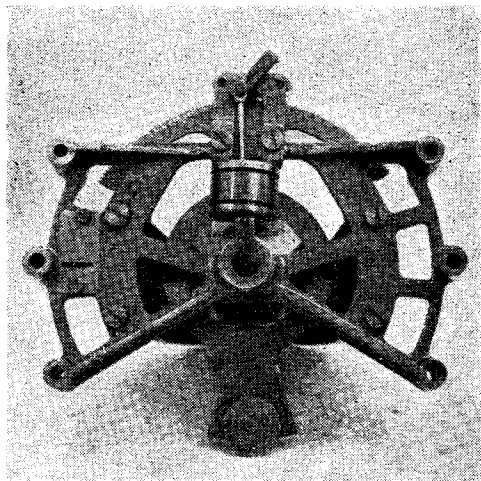
this type and cannot, therefore, describe them in detail.

The air turbine which drives the gyro in the simpler forms of instruments has cavities or "buckets" machined in the rim of the rotor, which serve the purpose of turbine blades, and utilise the kinetic energy of a jet of air directed into them from an air jet in the instrument casing. This can be fed by any convenient means, such as a small compressor or rotary blower, and in some cases the slip stream of the airscrew has been utilised. But in modern practice it is usual to create a partial vacuum in the instrument casing and utilise the air entering through the only available orifice, which is the jet nozzle. The advantage of this method, as compared with positive pressure, is that it reduces the air friction or "windage" inside the casing, which would resist the motion of the rotor. A comparatively low degree of vacuum—not more than about 5 in. of mercury—is used, and will rotate the gyro at a speed of over 10,000 r.p.m.

The rotor runs on ball-bearing pivots, the accuracy and finish of which must be of an extremely high order to enable the required speed to be obtained, with smooth and vibrationless running. It is probable that the efficiency of the turbine is not very high, as the blade form and jet attitude are not ideal, but it is, of course, adequate for its purpose, and readers interested in turbines could use one of this type as a basis for further experiments. Modifying the jet position would enable the flow efficiency of the air (or steam) to

be much improved, but it cannot be done while using the device as a gyroscope, as it would produce a side thrust or tilting moment, which would affect the forces on the instrument. It may, however, be noted that in certain types of directional instruments, the effect of jet deviation is used to assist precession and restore equilibrium of the gyro. In other cases the reaction or "jet propulsion" effect of air leaving the gyro casing, through controlled ports facing in different directions, is employed for this purpose.

Should attempts be made to drive the gyro by steam, some provision should be made for keeping condensed water out of the ball-races or they will soon be destroyed by corrosion. The turbine experimenter would probably find it advisable to sacrifice some bearing efficiency by reverting to plain bushes, which could be lubricated by oil carried through by the steam, as in internal lubrication of ordinary engines.



Front view of movement with piston damping device

### Availability of Instruments

As these articles are intended to assist readers who may wish to adapt or experiment with the instruments, only those known to be available at the time of writing are described, and every effort will be made to assist querists who do not find them readily available through local or other channels. But it is obvious that stocks of surplus goods, however large, are not unlimited, and no guarantee can be given that any of the items described will be available at the time their description appears in print. In many cases, however, it will be possible to suggest alternative sources of supply to those mentioned in the articles, or substitutes for the particular items, if exact requirements are stated. Both readers and traders can assist the writer in this respect by furnishing details of available goods, and any trader who may feel that his particular lines are being neglected should take the obvious remedy of bringing them to the notice of both the writer and readers of *THE MODEL ENGINEER*.

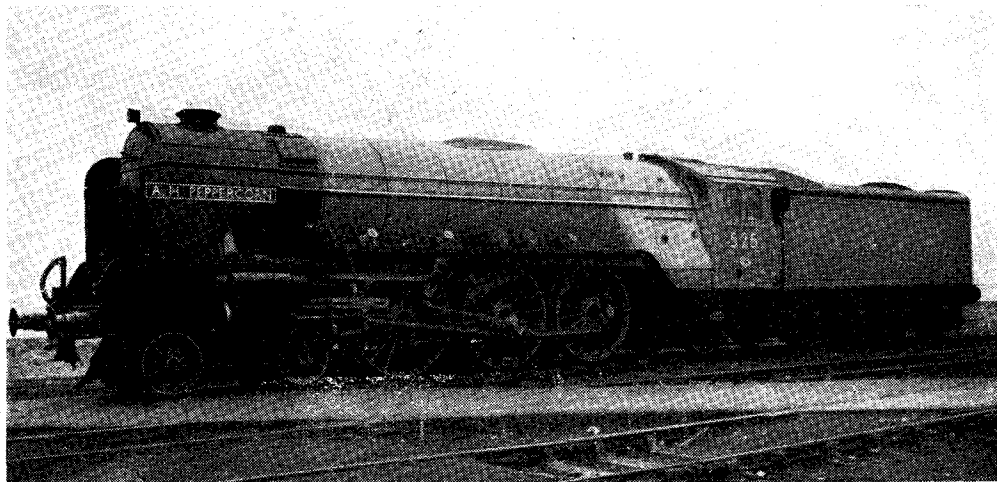
(To be continued)

# "PEPPERCORN PACIFIC"

A new engine which embodies considerable simplification  
compared with its immediate predecessors

THE first of a series of Pacific (4-6-2) express passenger and freight locomotives has just been completed at Doncaster Works and, resplendent in apple green livery, is now in service.

the middle cylinder acting on the leading coupled axle and the outside cylinders on the middle axle. The inside connecting rod and Walschaerts motion is identical with that used on the previous locomotives, while the outside



*L.N.E.R. engine No. 525, "A. H. Peppercorn," named after her designer*

The new engine is numbered 525, and on Thursday, December 18th, was named *A. H. Peppercorn* after her designer, the last Chief Mechanical Engineer of the L.N.E.R. The ceremony took place at Marylebone station, the naming being performed by Sir Ronald Matthews, Chairman of the L.N.E.R., who was accompanied by a number of directors and officers.

No. 525 is the 1,434th and the last locomotive to be built by the L.N.E.R. since the formation of the Company twenty-five years ago; it is also the 2,016th engine to be constructed at Doncaster Works.

The new engine has been classified "A2," and differs considerably in detail and appearance from those of the previous order built during the regime of Mr. Edward Thompson, now designated "A2/3."

The three cylinders of 19 in. diameter  $\times$  26 in. stroke have been brought closer together by moving forward the outside cylinders to the more orthodox position between the bogie wheels, thus shortening the exhaust ports and eliminating the external exhaust ducts. At the same time, the bogie has been brought back nearer to the coupled wheels, and the total wheelbase shortened by 2 ft. 7 in. As before, the drive is divided,

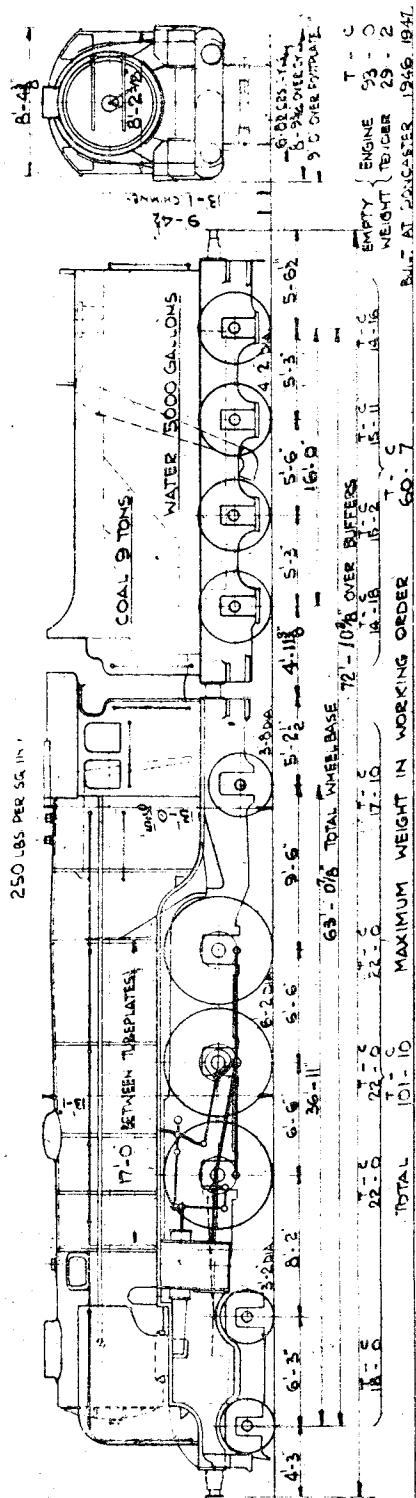
gear has been lengthened and closely resembles that used on the now numerous "B1" class of 4-6-0.

The boiler is unaltered in general dimensions and carries a pressure of 250 lb. per sq. in. The dome, however, has been replaced by a steam collector of the familiar L.N.E.R. pattern and the use of 3 per cent. nickel-alloy steel has enabled thinner barrel plates to be used.

The provision of a wider cab has enabled the vacuum ejector to be lowered and together with a vee front considerably improves the look-out. The cab mountings and controls follow the usual L.N.E.R. practice for Pacific engines but include electric lighting; the current for this and the head-lamps is supplied by a Stones turbo-generator situated on the front right-hand side of the footplate.

To reduce disposal time at the sheds, a hopper ashpan, rocking grate and self-cleaning smoke-box have been provided and these, together with the accessibility of the motion and valves, should assist the shed staffs in their routine examination.

The principal characteristics of the locomotive, together with those of the previous engines, are shown on the two diagrams.



*Diagram of Mr. Thompson's 4-6-2 design, which is interesting to compare with the later Peppercorn design*

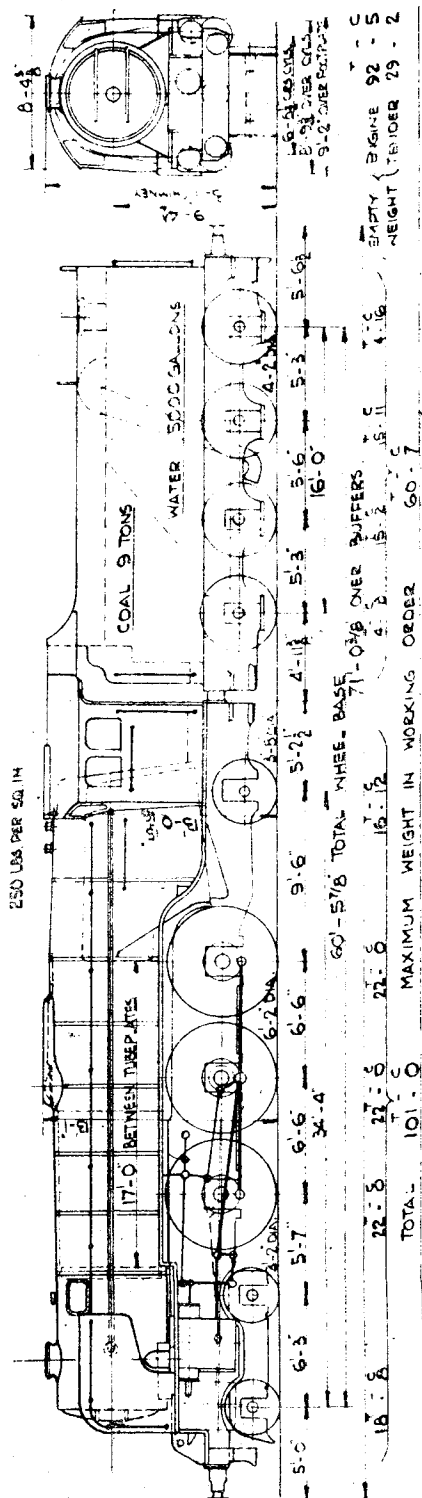
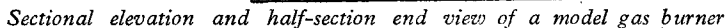


Diagram of the Peppercorn 4-5-2 design, showing principal dimensions

by A. Goodall, A.M.Inst.B.E.

lined furnace extension be fitted to the boiler base; the burner being mounted on the extension. The heated firebrick, and extra volume provided, all aid combustion and give better results than if the burner was arranged to fire into



It is strongly recommended that a refractory-

(Continued on page 173)

# IN THE WORKSHOP

by "Duplex"

## 4—The Test Indicator and Toolmakers' Buttons

WHEN setting work to run truly in the lathe the old-time mechanic used to hold a piece of chalk to the work, and the heaviest part of the marking showed him where it ran most out of truth. Although the millwright managed quite well with this rather crude method, nowadays a higher degree of accuracy is demanded and time is more valuable, or rather it is more expensive.

To facilitate this and other operations the test indicator was introduced, and many years ago the simple but efficient type shown in Fig. 1 could be bought over the counter for a modest half-crown but nowadays it doubtless costs more and is more difficult to obtain.

It will be evident from the drawing that the recording range of the device is limited to 15 thousandths of an inch, but its utility is greatly increased by the attachment shown, which enables readings to be taken either on the outer surface of the work, or from the inner part of a bored hole.

To enable the indicator to be readily mounted in the lathe, the tool-post holder illustrated in Fig. 2 was devised; this provides a full range of adjustment for setting the device to work. A rather more elaborate instrument made by Messrs. Starrett is shown in Fig. 3. Here,

there is a central zero position with a range of movement of 30 thousandths of an inch in either the upward or downward direction, as determined by rotating the contact-piece which engages the work.

As depicted, the device can be attached to a base-piece for clamping in the lathe tool-post, or it will fit on to the pillar of a standard surface gauge.

### The Dial Test Indicator

Further development of this instrument has given us the modern dial test indicator, of which a typical example made by Messrs. Brown & Sharpe is illustrated in Fig. 4. In this

case, as its name implies, measurements are clearly shown by a clock hand rotating over the face of a graduated dial. The dial, which is usually divided into half-thousandths of an inch, can be set to the zero position by rotating the bezel. Here, the range of movement is much greater than in the preceding types, and usually amounts to some quarter of an inch.

The base member, as will be seen, is provided with four corner gauge or register pins for locating the instrument against the lathe shears or other guide surfaces.

As an additional fitment, an attachment shown in Fig. 5 is obtainable to enable the instrument to register against either external or internal surfaces. Where a test indicator is often required for use in the lathe, it will be found that a ready means of mounting it for either external or in-

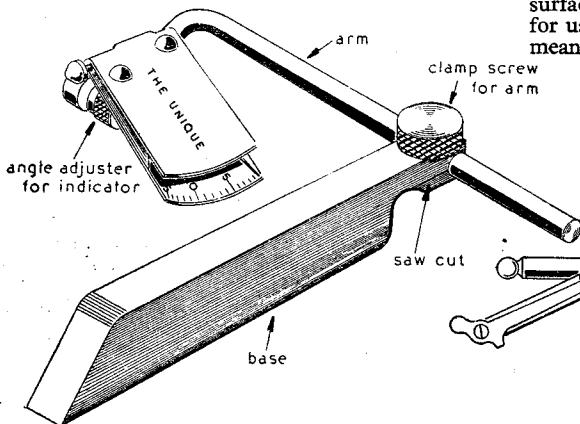
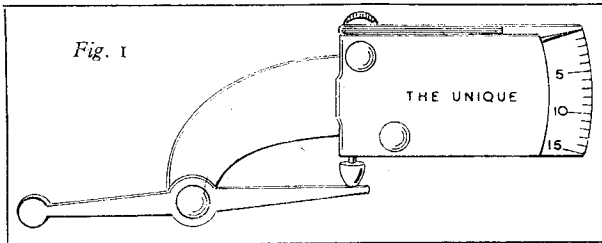


Fig. 2

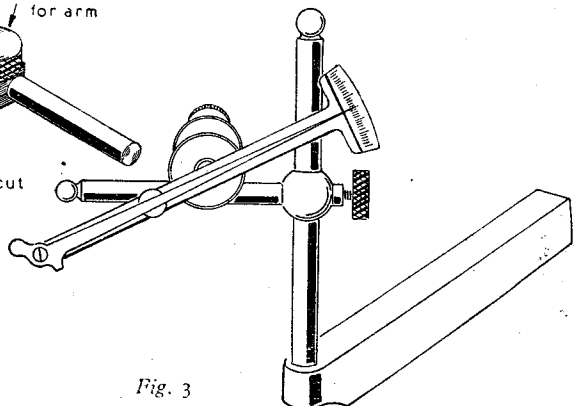


Fig. 3

ternal work is a great advantage. The holder shown in Fig. 6 was devised for this purpose, and moreover, it is quite easily made. The swivel clamp of the indicator is secured to the cylindrical portion (A), and the clamping-piece (B) is fixed to the lathe tool by tightening the swivel-headed screw (C).

When so mounted, the indicator is readily adjusted to the work by turning the lathe cross-slide feed-screw.

In making this holder it should be noted that, to assemble the clamp screw, its revolving head should be secured in place by expanding the drilled end of the screw with a centre-punch, inserted through the hole into which the part (A) is screwed. A few light hammer blows should be sufficient to secure the head without preventing its free rotation.

### Setting Work with the Test Indicator

With a view to using the test indicator in the lathe, it should be clamped as described in the tool-post or to the lathe tool; as an alternative method, it may be attached to a base stand as shown in Fig. 4 or to the pillar of the surface gauge, and if desired the gauge pegs can be used to position the instrument on the lathe bed. At this point it will be opportune to describe the method commonly used to set work—such as a round shaft—truly in the four-jaw independent chuck. A methodical plan should be adopted, as haphazard loosening and tightening of the chuck jaws when chasing an error will result in loss of both time and patience.

At the outset, the shaft is lightly gripped in the chuck, with the jaws set as nearly central as possible by reference to the circles inscribed on the chuck face. If the mandrel is then turned by hand, the work should be found to run fairly truly.

Whilst the mandrel is slowly turned, the contact point of the indicator is advanced until the needle shows some deflection at all points; turn to the point of least deflection of the needle, and set the scale to zero; then turn to the point of greatest deflection and note the reading. If, for example, the reading is 0 at No. 1 jaw and 80 at the opposite jaw, i.e., No. 3, then rotate the work until the zero position is again reached, and slacken No. 1 jaw and screw in No. 3 until half the difference between 0 and 80 is reached, that is to say the needle is brought to the 40 mark. Rotate the work again and correct any remaining errors in the same way.

The final correction, involving a thousandth of an inch or so, should be made solely by tightening the chuck jaws and with reference to the indicator, so that as the jaws are tightened at the completion of the operation the work is brought into and not out of truth. When a simple type of test indicator with a limited range of movement is used, the procedure is similar in principle, but at first probably only the high point can be detected, and the error must be corrected until the total eccentricity falls within the range of the instrument, and both the high and the low points are indicated on the limited scale.

### The Centre-finder or Wobbler

The centre for machining a bore or a bearing

hole is often indicated by drilling with a Slocombe centre drill, and when this hole has to be drilled and finally bored to the correct size, the work is usually held in the four-jaw chuck or is attached to the lathe faceplate. Prior to this, the hole must be accurately centred, and, if the back centre is pressed in firmly while the work is being clamped in place, a fairly accurate setting will be obtained. For the final setting, a device, shown in Fig. 7, called a centre-finder or wobbler should be used. The body of this tool consists of a length of some 6 in. of turned, or ground, mild- or preferably silver-steel, the essential point being that it should be straight. After the first world war, ground drill blanks  $\frac{5}{16}$  in. in diameter and 6 in. long made by the Union Twist Drill Co. could be bought very cheaply, and a stock of these acquired at the time has proved most useful for tool-making.

Readers are strongly advised to collect good material of this nature whenever the opportunity occurs.

After the wobbler shaft has been set in the four-jaw chuck to run quite truly, the point is turned to an included angle of 60 deg. by setting over the top slide of the lathe.

There is no need to harden the point if silver-steel is used, for the device will rotate with the work and not rub in it. The shaft is then reversed in the chuck, and, when it has again been set to run truly, a Slocombe centre drill with a  $\frac{1}{8}$ -in. diameter body, mounted in the tailstock drill-chuck, is then run into the work until the parallel part of the drill has entered for some  $\frac{1}{8}$  in. A  $\frac{1}{8}$ -in. diameter twist drill is next entered in the same way for a depth of some  $1\frac{1}{4}$  in.; this is followed by a No. 13 drill, and, finally, the bore is finished with a well-lubricated  $\frac{3}{16}$ -in. reamer, supported against the back centre, and turned by hand while it is fed forward by the tailstock. In this way, if due care is taken and the work is not hurried, a hole truly centred, at any rate at the tail end of the shaft, should result. Next, a well-fitting steel plunger is turned a sliding fit in the bore, and a Slocombe centre hole is drilled centrally in the outer end.

The spring fitted to operate the plunger should be slightly closed where it embraces the neck of the plunger, and as it is opened out at its inner end to engage the bore frictionally, it will retain the plunger in place.

When in use, the pointed end of the centre-finder is entered in the Slocombe centre in the work, and the lathe back centre is fed into the Slocombe recess in the plunger, until the latter is flush with the rear end of the body. In this way, as long as the body is bored truly at its outer end, the Slocombe centre in the plunger will be centrally located even should the drill have wandered in the deeper part of the bore. To test the device, mount it as described above and, after bringing the test indicator into contact with the body, rotate the device and note the deflection, if any, of the indicator hand. Even if there is any slight eccentricity towards the rear end of the shaft, this will be negligible if readings are taken, as they always should be, close to the truly centred point. To use the wobbler, apply it to the work as already described and engage the test indicator near the point.

The work is then adjusted to eliminate any eccentricity present in exactly the same way as was described for centring a shaft, only in this case the tip of the centre-finder represents the shaft.

### The Use of Stub Mandrels for Centring Work

So far, we have seen how to set work in the four-jaw chuck to run truly with reference to

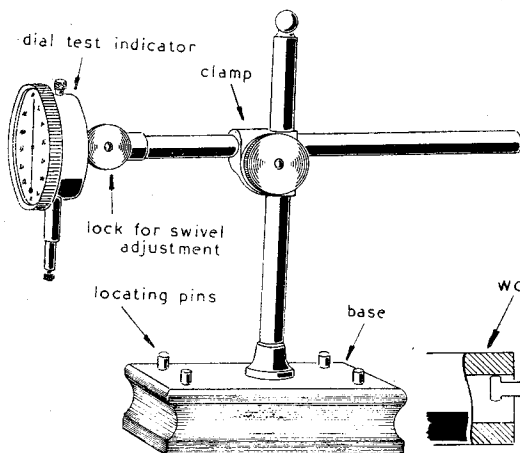


Fig. 4

its outer or inner surface, and also the method of setting a drilled centre so that it lies truly central. In addition to these, another problem frequently arises, i.e., setting parts in the lathe, such as a cylinder, a bearing bush, or a crankcase end-plate, which has already been finish bored, but after removal from the lathe requires a further turning operation, truly concentric with the first, to complete the machining. A very simple and, at the same time, a very accurate method of ensuring both concentricity and true alignment is by the use of stub mandrels, and this procedure should always be adopted in preference to using the four-jaw chuck where accuracy in these respects is essential.

For this purpose, a short length of steel, brass, or aluminium alloy, mounted in the self-centring

face, with the assurance that true concentricity will be preserved during subsequent machining.

These mandrels should not be removed from the lathe until the machining of the work has been completed, and, whenever a stub mandrel is again brought into use, it should be re-machined if real accuracy is to be ensured.

Always oil the mandrel before engaging the work, to prevent seizing and scoring of the machined surfaces.

### Toolmakers' Buttons

This is another device designed for setting work accurately in the lathe. When two or more

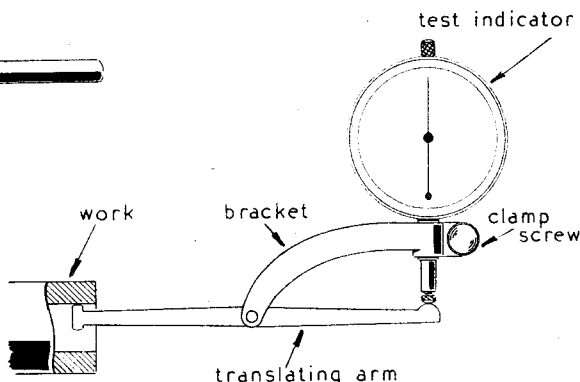


Fig. 5

holes have to be machined with their centre distances within very close limits of accuracy, no attempt should be made to do this by merely marking-out the centres and then drilling them. In the first place, even if the marking-out could be accurately carried out without the use of very expensive equipment, it would be pure chance if the centre-punch mark, required to start the drill, were also accurately located, for here an error of from 2 to 5 thousandths of an inch, or even more, may arise in spite of great care being taken.

In the second place, drills cannot be relied on to follow the centre-punch mark exactly. It will be evident that, if all these possible errors are added together, the final position of the drilled hole may not be at all as intended, and it would be

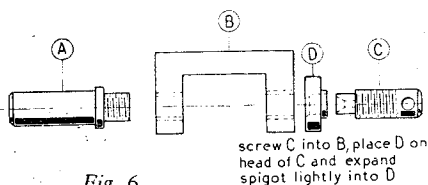


Fig. 6

or other mandrel chuck, is reduced in diameter for a length sufficient to engage the bore of the part and to hold it securely, while further turning operations are carried out.

Likewise, a length of material held in the lathe chuck can be bored internally to hold truly a part, which has been turned on its outer sur-



Fig. 7

only a matter of luck if the errors tended to cancel out. Holes can, of course, be accurately drilled and spaced by using a special jig, but even in this case the jig guide bushes must be located by a method such as that now described. Let us suppose that it is required to bore in a plate two holes that are to serve as bearings for a pair

of shafts carrying gear wheels, such as the pinion shafts of a clock movement. It will probably be well known that gear centres must be very accurately spaced, otherwise the gears will be noisy when running, undue wear of the teeth will occur, and the correct motion will not be evenly transmitted from shaft to shaft.

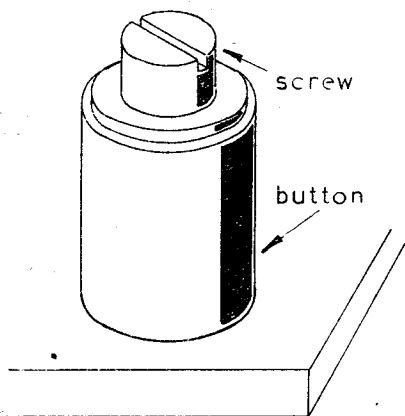


Fig. 8

How then can these difficulties be overcome without the use of expensive equipment? The answer is, by means of toolmakers' buttons, and the method of using them is now set out in detail in order to show how a high degree of accuracy can be ensured by the use of simple equipment.

The toolmakers' button, depicted in Fig. 8, is a short hollow steel cylinder ground truly parallel, and with the end faces machined exactly square with the long axis. In order to facilitate

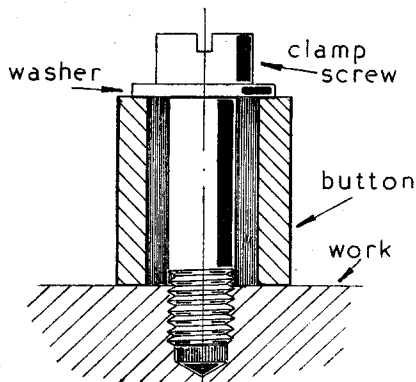


Fig. 9

calculations when setting the button, the outside diameter is ground to an exact fraction of an inch; thus, buttons are obtainable with diameters of 0.300 in., 0.400 in., 0.500 in. and 1.00 in., and all are  $\frac{1}{2}$  in. in length, except the last, which is made 1 in. long.

From the section of the button shown in Fig. 9, it will be apparent that ample clearance is allowed for the central  $\frac{1}{8}$ -in. fixing screw, to

afford a good range of adjustment when the button is being set on the work; in this connection, it should be noted that, if accurate work is to be expected, the button must be set up only on a truly-machined surface, for, as will be apparent later, any tilting of the button will inevitably cause errors when positioning the work for machining. To return to our problem, the centres of the shafts must first of all be marked-out as accurately as possible on the plate, and the centres thus indicated are then drilled and tapped for the fixing screws of the buttons. Approximate accuracy only is here required, for errors of location will be corrected when setting the buttons. As, in this case, the problem is solely to locate the two shaft bearings at an exact centre-to-centre distance, the first button may be attached in position by measurement with a rule from the edges of the work, as is shown in Fig. 10. The use of the depth gauge instead of a rule will facilitate this operation, as the measuring rule is then maintained truly at right-angles with the edges of the work. If a button of  $\frac{1}{2}$  in. diameter is used, half the diameter of the button, that is to say  $\frac{1}{4}$  in., must of course, be added to each

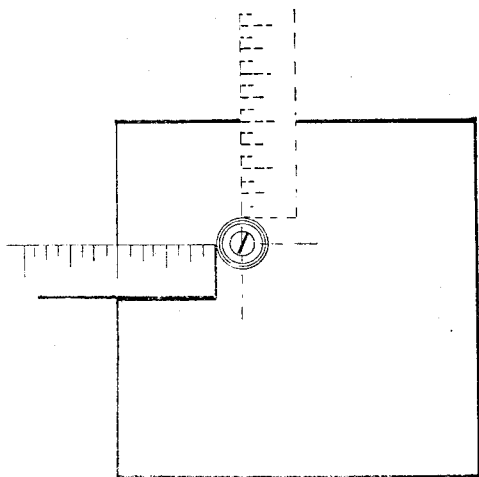


Fig. 10

measurement. Where the first button has to be located with a high degree of accuracy, the measuring equipment generally used is more elaborate, and this problem may be discussed in some future article. When the first button has been firmly secured, the second is lightly clamped in place and adjusted by tapping, until a micrometer reading taken over the outer diameter of the two buttons shows that the centre distance is correct. The measurement to be set with the micrometer is found by adding together the gear centres distance and half the diameter of each button, or the diameter of one button when both are of equal diameter. For example, if the gear centres distance is 2 in. and buttons of 0.400 in. diameter are used, the check measurement is: 2 in. + 0.400 in. = 2.400 in. When the buttons have been accurately located and firmly secured in place, the plate is set up on the lathe faceplate with one button running as nearly true as pos-

sible. Fig. 11 shows the method of making the final adjustment by means of the dial test indicator, as has already been described for centring a shaft held in the four-jaw chuck. When the button has been set to run exactly true, the plate is firmly clamped to the faceplate, and the button is removed, as it has served its purpose.

The remaining screw hole is then enlarged by drilling well under the required bearing size, for it is possible that this hole will be somewhat eccentric, and sufficient metal must be left for the bearing to be finally bored out to the correct

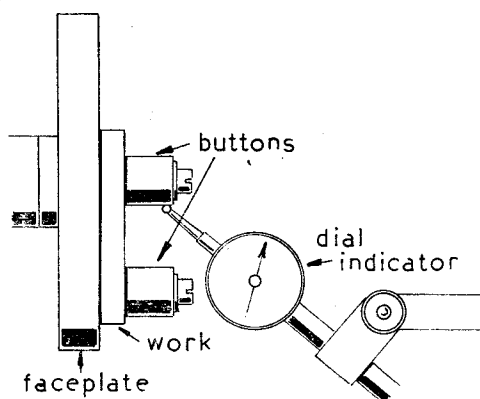


Fig. 11

finished size by means of a fine-pointed boring tool. When the first hole has been machined to size the plate is released, and, after the second button has been set to run truly, the second bearing is finished to size, as in the case of the first.

As far as the small workshop is concerned, there is no need to buy commercially-made buttons, for these can readily be made up from silver-steel bar and, if necessary, hardened, but the latter process is, perhaps, better omitted, as it may cause distortion. In any case unhardened buttons should be sufficiently resistant to wear and damage if reasonable care is exercised. A short length of rod is held in the chuck, and, after its end has been truly faced, the central bore is drilled and afterwards finished with a small boring tool if desired. The rod is then turned parallel

and to the required diameter as measured with a micrometer. Following this, the hollow cylinder is parted off to length, and, if found necessary, the parted surface is accurately faced with the button mounted on a stub mandrel, as previously described. A good quality stock fixing-screw may be used, but the washer should be of sufficient diameter to engage the wall of the button in all positions.

It sometimes happens that there is difficulty in setting the first button with the test indicator owing to the closeness of the second; and, to

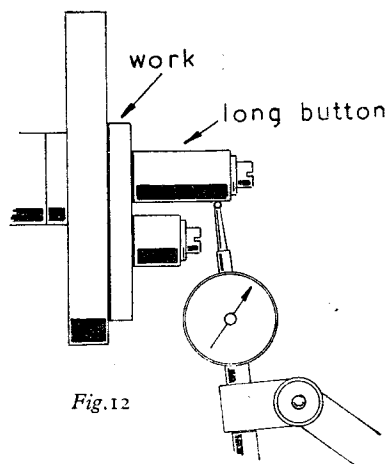


Fig. 12

overcome this trouble a long button may be used in the first position, as shown in Fig. 12. This will also allow the indicator to be used to better advantage with its contact spindle more nearly at right-angles to the work.

A further problem at times encountered in the workshop is the location of a gear-driven shaft, such as a half-time shaft, in correct relation to a crankshaft after the bearings of the latter have been machined. In this case, the crankshaft bearing in the crankcase end-plate is fitted with an accurately turned parallel spigot, and the projecting portion of this fitting is used in the same way as a button for locating a second button, representing the position of the half-time shaft bearing. The latter button, when firmly secure in place, is set to run truly in the lathe and the bearing is bored as in the previous example.

## A Model Gas Burner

(Continued from page 168)

When experimenting to find the performance of this burner applied to a particular model, drill four fine jet holes to begin with, test the burner and, if satisfactory, do *not* drill any more jet holes. There is no sense in burning more gas in the furnace than you need to keep up full pressure under load. Fit a screw-down type model stop valve on the burner and the burner flame can then readily be adjusted at the boiler. Copper pipe from the valve, led away to the edge of the

model baseboard ( $\frac{3}{16}$  in. bore is ample size), will give a realistic appearance to the model.

Lighting up is simple. Close the air register, turn on the gas and light through  $\frac{3}{16}$  in. hole in top bar of the fixed register. Gradually open the air register and open fully the gas valve. The burner should run well with full air, when the gas valve is full open down to half open. When smaller, or a lesser number of jets than shown are used, it may be necessary to use a lesser air register opening.

# A Makeshift "Dividing-Head"

## by "1121"

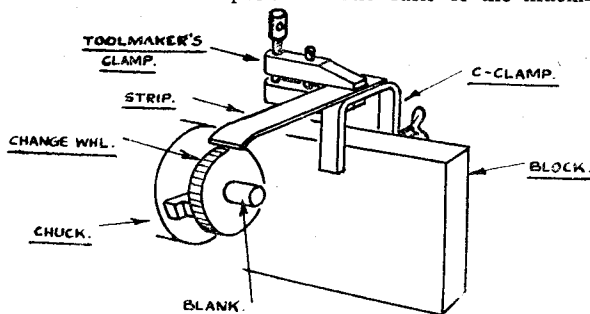
**M**OST readers with lathes know and have probably used the principle of employing a change-wheel for a division-plate, when the correct wheel happens to be available, and in conjunction with it the method of cutting the teeth of gears, ratchet-wheels, etc., by means of a lathe-tool held on its side in the tool-post.

The average model engineer will have no objection to fitting some sort of indexing plunger to his own lathe to engage with the teeth of the change-wheel being used, but this is one of those jobs that seem to get neglected when there is more productive work to be done, and then, when the need for the indexing attachment comes along, it is considered an awful fag to have to start drilling and tapping holes in the machine and making up all sorts of brackets and things just to cut one little wheel.

The writer was recently faced with a "rush job," consisting of the cutting of a small 24-toothed ratchet-wheel as quickly as possible, and, furthermore, as it had to be done on a lathe which was not his own property, the business of designing, making and fitting a proper indexing

down for the purpose. The section, Fig. 1, should make this clear. If the ratchet-wheel were to be made smaller than the bore of the change-wheel, the latter could have been pushed on over the top of the ratchet-wheel diameter, as shown in Fig. 2.

The basis of the indexing gear was a large lump of cast-iron which happened to be handy, measuring about 9 in. square by 2 in. thick. This was a fairly substantial foundation, and was stood behind the lathe, on edge, but just to make sure it couldn't move, it was wedged between the lathe bed and the wall at the back, with sundry



Sketch of the dividing gear

large pieces of wood. To the top of it was fixed a C-clamp, of the flat strip variety, and to the back of this clamp was secured, with a toolmaker's clamp, a strip of  $\frac{1}{16}$  in. mild-steel, about  $1\frac{1}{2}$  in. wide, which was bent slightly so that its forward end bore down on and into the teeth of the change-wheel. The perspective sketch should make all this clear.

This set-up looks a most horrible contraption, and no doubt many theoretical objections to it could be raised without any trouble at all, but

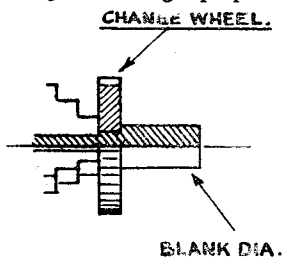


Fig. 1

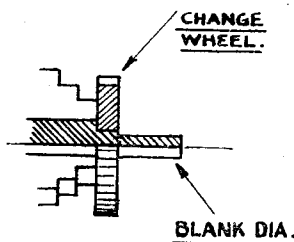


Fig. 2

attachment was quite out of the question, and the following rig was devised.

The change-wheel (48 teeth was the nearest we had) could not be mounted in the usual place on the back end of the headstock mandrel, as this is equipped on this particular lathe with a permanent wheel, which could not easily be changed over, and so the 48-toothed wheel was pushed instead on to the actual brass bar from which the ratchet-wheel was to be made. As the bore of the change-wheel was smaller than the required outside diameter of the ratchet-wheel, it had to be mounted between the chuck and the full diameter of the brass bar, on a length turned

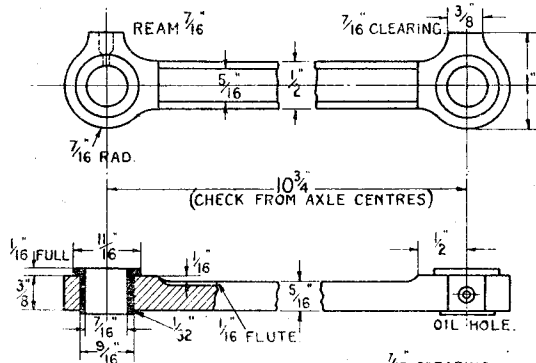
the fact remains that in actual use it gave a most beautifully positive result, the wheel being "clicked" round two teeth at a time, and hardly needing to be held back against the stop while each tooth was shaped.

It should be hardly necessary to remark that the blank was turned a complete revolution at each setting of the cross-slide, and only a small cut was applied each time. By setting the top-slide, a position was found which enabled the cutting-stroke to be performed comfortably with the quick-traverse handle on the saddle, obviating a lot of tiring mangling with the slow-feed handle at the end of the lead-screw.

# Coupling-Rods for "Maid" and "Minx"

## by "L.B.S.C."

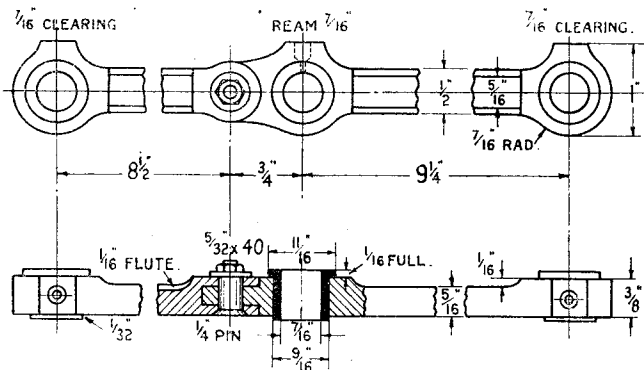
ANYBODY who owns, or has the use of a milling machine, the table of which has not less than 10 in. of longitudinal movement, will find the coupling-rods of the "Maid of Kent" a fairly simple job; but those who haven't are in for a bit of "slogging" if they cut the rods from the solid. Each rod calls for a piece of 1-in. by  $\frac{3}{8}$ -in. mild-steel bar 11 $\frac{3}{4}$  in. long; that is a tidy lump to begin with! My own milling



*Coupling-rods for "Maid of Kent"*

machine would just take it, and to make the rods I should begin by marking one out, not forgetting to check with the axle-centres, which should coincide exactly with the coupling-rod centres. A small hole would be drilled at each end, say  $\frac{1}{8}$ -in. or No. 31, and the marked out rod used as a jig to drill the second one. The two pieces would then be temporarily held together by pieces of  $\frac{1}{8}$ -in. round steel in the drilled holes, and clamped to the table by a clip and bolt at each end, being far too long to hold in the machine vice. I have a small slabbing cutter, 1 $\frac{3}{8}$  in. diameter and 1 $\frac{1}{8}$  in. wide; the teeth are cut spirally, and the way that cutter can mow through solid steel is just nobody's business. It doesn't chatter either, and as it always works under a drip of cutting oil from a can hung on the overhead arm of the machine, it rarely needs grinding. "Houghtolard," "Vacmul," and "Cutmax" all work equally well with it, diluted with one-third their bulk of ordinary paraffin oil. Incidentally, tell it not in Gath, I gave eighteenpence for it as "Government surplus" at Buck and Ryan's, after the Kaiser's war.

Well, I guess that cutter would make an easy job of removing the surplus metal from top and bottom of the rod blanks, and one side of each piece of bar. The flutes would be formed by bolting the rods to the table, recessed side up, and running them under a  $\frac{1}{16}$ -in. by 2 $\frac{1}{2}$ -in. end-and-face cutter on the arbor. Then before going any farther, I should press all the wheels on the axles, open out the pilot-holes in the ends of the rods to  $\frac{1}{16}$ -in. clearing, and try them on the crankpins. If all O.K., the ends of the rods would be rounded off by aid of my vertical milling-machine. A piece of square bar, with a  $\frac{7}{16}$ -in. peg about  $\frac{3}{8}$  in. long on the end of it, would be placed vertically in the machine-vice on the table, one end of the rod put over it, and run up to a  $\frac{1}{2}$ -in. or  $\frac{3}{8}$ -in. end-mill, with teeth on the side, in the socket of the vertical spindle. Swinging the free end of the rod around, the peg acting as fulcrum-pin, would enable the side teeth of the end-mill to cut away the end of the rod, to the shape of the boss shown in the illustrations. The holes in the bosses would then be finally opened to  $\frac{1}{16}$  in., the bushes turned and pressed in, and the oil-holes drilled; any slight irregu-



*Coupling-rods for "Minx"*

larities left by the end-milling of the bosses, would be cleaned up with a file.

### Pressing the Lathe into Service

As the slides on the average small lathe have nothing like sufficient travel to do the job by any of the usual methods of milling in the lathe, some other method is called for; and we might, with advantage, take a lesson from the late Tom Averill, who was a real lad at devising ways and means, and a dab hand at locomotive building. Mr. Averill would have centred the ends of the rod blanks, after marking out, and then mounted each rod between centres, turning away the surplus until the tool touched the marked

lines showing the width of the centre-part of the rod. The rods would, naturally, be "round-backed" between the bosses, but a file would soon have flattened them; and the amount of metal to be filed away, would be only a small fraction of the amount that would have to be removed if the rods were sawn and filed from the solid bars. The surplus metal at the ends could also be turned away, and a file used to finish the job.

### How to Build Up the Rods

By far the easiest method for those whose equipment is limited, is to build up the rods, for practically no machining is needed. A jig will be required, on which to assemble the rods for brazing; this is a piece of steel bar, any convenient section that you may have handy, and about a foot long. On the centre-line, make two centre-pops  $10\frac{1}{2}$  in. apart, drill them No. 32, and drive in two pegs of  $\frac{1}{8}$ -in. round steel, leaving about  $\frac{3}{8}$  in. projecting. Over this put a piece of  $\frac{1}{8}$ -in. asbestos millboard; thicker stuff will do, if you have it, but don't have it any thinner. If you've only  $\frac{1}{16}$ -in. sheet, use two layers. The  $\frac{1}{8}$ -in. pegs should project up through holes in the millboard. Chuck a piece of  $\frac{1}{4}$ -in. round mild-steel in the three-jaw (a stub end of steel shafting is just identical); face, centre, drill down about 1 in. of depth with No. 30 drill, and part-off two  $\frac{3}{8}$ -in. slices. If your lathe doesn't like parting-off to this diameter—the average small lathe of today doesn't!—saw off to full length, chuck in three-jaw, and face each side to correct thickness. Put one of these pieces over each peg on the jig; then cut a piece of  $\frac{1}{2}$ -in. by  $\frac{1}{16}$ -in. mild-steel bar, to fit nicely between them. File up two pieces of steel, as shown in the illustration, to form the oil-boxes on top of the bosses; they aren't essential, but the bosses do not look right without them. Then either braze or Sifbronze the joints between bosses, rod and oil-box tops, with the assembly still on the jig. Let cool to black, quench in clean cold water, and clean up. The rawest tyro should be able to make a neat job of the brazing; all that is needed, is to put a dab of wet flux on each joint, heat it to a bright red with the blowlamp or blowpipe, and touch it with a bit of 16-gauge soft brass wire, or Sifbronze rod. Either will melt instantly, flow into the joint, and leave it perfectly neat and sound. Open out the holes in the bosses to  $\frac{1}{16}$  in. clearing, press on the wheels, and try the rods in position before bushing them.

### How to Press On and "Quarter" the Wheels

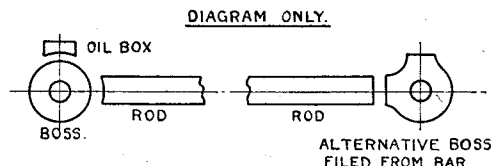
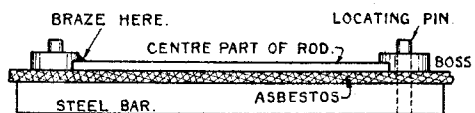
If you haven't already done it, press one wheel (with balance-weight opposite boss) on each of the straight axles, trailing only for the "Maid," leading and trailing for the "Minx." To save any chance of the axleboxes getting mixed up, poke the axles through the axleboxes, and put the other wheel on by hand, as far as it will go. Then take the hornstays off, so that you can lift the assembly right out. I have described in full detail, many times, how to "quarter" the wheels; but so many beginners have written lately, saying that they cannot get back issues, and begging me not to refer back when avoidable,

that I will briefly repeat the operation. Stand the wheels on anything flat, such as the lathe bed, or drilling-machine table, with the crankpins set as near to right-angles as you can set them "by eye." The right-hand crank should lead. Now set up your try-square, with the stock on the flat surface alongside the wheel, and the edge of the blade passing across the centre of crankpin and centre of axle. Next, take your scribing-block or surface-gauge, and set the needle to the centre of the axle on the other side. Set the crankpin to the same height. When the crankpin centre is "spot on" to the scribing-block needle, on one side, and the blade of the try-square passes across the centres of both crankpin and axle on the other side, Bob's your uncle. Press the wheel right home, and replace the assembly in the frames.

The crank axle isn't much more difficult. You don't have to bother about the position of the balance-weights, as the suppliers of castings will have seen that they are in correct relation to the crankpin bosses in the wheels; I gave the information direct to those who asked for it. On both "Maid" and "Minx," the inside cranks are set directly opposite to the outside cranks; 180 deg. to be exact. I arranged them thus, because they are set that way on the Ashford Lr's and the Vulcans; not because I prefer it, for I think the Stroudley idea of having inside and outside cranks "in step" is far better. The pull and thrust is taken direct, and not by using the axleboxes as fulcrum pin sockets for a lever of the first degree, with consequent wear on the hornblocks and axleboxes. The argument that a heavier balance weight is needed, doesn't "hold water" in a manner of speaking, because it isn't any heavier than one used with outside cylinders. In fact, with balanced inside cranks, it may be lighter. However, we needn't go into that matter in full detail here! The coupled wheels that go on the crank axle in both "Maid" and "Minx," are those with the weights on the same side as the crankpin bosses. Put one of the axleboxes on the outside of each crank, and put the wheels on by hand, as far as they will go. The extreme ends of the wheel-seats should be eased with a file, so that they will just start in the holes in the wheels.

To set the outside crankpins dead opposite to the inside cranks, is a job any intelligent kiddy could do in a few minutes. Stand the assembly on something flat, as described above. Set your try-square with the stock on the flat surface, and the blade against one of the crank webs full length. That crank must then, naturally, be exactly vertical. Set the needle of the scribing-block level with the centre of the axle, and then set the crankpin of the opposite side wheel to the same height, but opposite to the inside crankpin. After you get that right, don't bother about the inside crank any more; put your try-square against the wheel you have just set, and follow the procedure given above, for setting the wheel on the other side. Then jam a bit of packing between the crank webs, press the wheels right home, and re-erect the complete assembly in the frames. If the coupling-rods are now temporarily placed on the crankpins, the wheels should turn freely without any tight places.

If there is any sign of tightness, try one side at a time, and watch very carefully the dead centre points. You should be able to see which side makes contact first, and that side should be eased out with a round file until there is an equal amount of clearance at each side of the pin. The holes can then be opened to  $\frac{7}{16}$  in. diameter, and the bushes fitted; but I'm "running ahead of the time-table," as I haven't yet mentioned the knuckle-joint needed for the coupling-



*How to build up coupling-rods*

rods of the "Minx." That is what comes of trying to give instructions for both engines at once!

### How to Make the Knuckle-joint

The main parts of the coupling-rods for the "Minx," and the end bosses, are made in the same way as described above for the "Maid"; the difference is in the centre, or driving boss, and the knuckle-joint. Beginners will, of course, realise that a vertical knuckle in the rod is necessary, so that all three axles can follow the "umps and 'ollers" of a poorly laid or maintained line, and safely negotiate crossing frogs and so on. To allow for the knuckle extension, the back halves of the rods will each need a piece of 1-in. by  $\frac{3}{8}$ -in. steel approximately 11 in. long, if cut from solid, and these can either be milled, or turned between lathe centres, as described above. The difference from the "Maid's" rods is that an extension is left at the driving boss of each rod, to form the tongue that fits in the forked end of the shorter half of the rod.

The latter will need pieces of steel  $9\frac{1}{2}$  in. long only. The leading boss is the same as the "Maid's," but the knuckle-boss is smaller, being only  $\frac{7}{16}$  in. radius. It has no oil-box, being completely rounded off, and is slotted as shown in the cross section. This slot can be formed by the same process as described for valve-gear forks in the "Lassie's" valve-gear, viz. by clamping the rod under the slide-rest tool-holder, and feeding it up to a circular slotting cutter  $\frac{3}{16}$  in. wide, mounted on an arbor between centres, or on a stub-mandrel held in three-jaw. A narrower cutter can be used, if you take more than one "bite." Beginners might be interested to know that suitable cutters for jobs like these are easily home-made, using

a disc of cast-steel of suitable thickness, cut from a scrap bit of gauge-steel, or "ground flat stock" as it is known in the trade. Any diameter over  $1\frac{1}{2}$  in. would do. Drill a hole in the middle to suit your spindle or stub-mandrel (an old bolt will do for the latter) mount the bit of steel on it, and turn to the largest diameter that the piece will allow. File the teeth by hand; it doesn't matter a bean if they are not regular—in fact, a cutter with irregular teeth seldom or never chatters! Harden and temper to dark straw; the tempering is done by brightening up one side of the cutter, laying it on a fairly thick piece of sheet-iron, and heating up over a bunsen, or the smallest burner of the domestic gas stove. Plunge in cold water as soon as it turns yellow.

The tongue of the longer rod is pin-drilled down each side, until it just fits the fork. Beginners, again, can make their own pin-drill by making a cutter exactly the same shape as the slotting-drill which was recently illustrated; but instead of filing a nick in the middle, drill a No. 32 hole in the end for about  $\frac{1}{2}$  in. depth, making that the first operation. After filing the cutter to shape, and hardening and tempering it, drive a bit of  $\frac{1}{8}$ -in. silver-steel into the hole, leaving about  $\frac{1}{4}$  in. projecting, to form the pin. This pin fits the pilot hole in the extension boss of the longer half of the coupling-rod; and if used in the ordinary way, either in drilling-machine or lathe, the pin-drill will cut away the superfluous metal at each side, leaving a tongue to fit the fork as mentioned above. The surplus around the pin-drilled tongue may be filed off, or it can be removed by the same process as described earlier, for rounding off the bosses of the rods. The rounded-off end of the forked boss should fit snugly in the recess, as shown in the illustration.

The hole through both fork and tongue is opened out to  $\frac{1}{4}$  in., and the plain side—that is, the back of the rod—countersunk. A pin is then turned to fit it, from  $\frac{3}{8}$ -in. round-mild steel; a kiddy's practice job which needs no detailing. The end is shouldered down to  $5/32$  in. diameter,

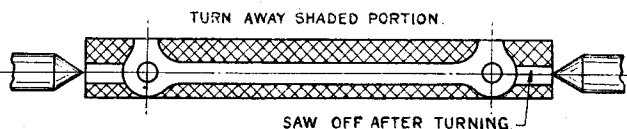


DIAGRAM ONLY.

*How to make coupling-rods by turning*

screwed  $5/32$  in. by 40, and a nut made to suit, from  $\frac{1}{4}$ -in. hexagon steel. The whole doings can then be assembled as shown, and any part of the pin projecting from the back, should be filed off flush, so that it will not foul the wheel bosses.

After the rods have been tried on the crankpins in the wheels, with plain  $\frac{7}{16}$ -in. clearing holes in the bosses, and made to run easily, they can be bushed. First open them out to  $\frac{9}{16}$  in. diameter, scraping off the sharp edge around the hole. The bushes can be turned from  $\frac{1}{4}$ -in. diameter bronze or gunmetal rod; don't use soft brass,

(Continued on page 180)

# Hot-Air Engine Cycles

by D. A. Wrangham, M.Sc. (Lond.), Sen. Wh.Sc., A.C.G.I., D.I.C., M.I.Mech.E.

THE article on "The Hot-air Engine" by B.C.J., which appeared in THE MODEL ENGINEER of December 18th, 1947, was very timely, since the development of the gas turbine has caused attention to be directed to the various ideal cycles on which former hot-air engines were supposed to operate.

The jet engine operates on the old Joule cycle (see Fig. 1), since this cycle is much easier of practical attainment in rotary machines than the Stirling and Ericsson cycles.

By reason of the adiabatic operations of the Joule cycle being replaced by isothermal operations, in which the entire heat supplied is converted into mechanical work, the Stirling and Ericsson cycles permit the highest thermal efficiency attainable. This is given by

is particularly fortunate, since the efficiency of rotary compressors is not high. In practice, however, it is extremely difficult to supply heat to the working fluid so as to keep in step with the work done or to remove it at this rate during compression.

In high-speed modern engines there is not the time, surface area nor, if the engine is to be efficient, the temperature difference to promote the requisite flow of heat through the cylinder wall or the casing of the turbine.

To obviate this difficulty stage compression and stage expansion, with interstage coolers or heaters, is resorted to. The surface area of these heat exchangers is not restricted like the cylinder walls, and more time is available for the transference of heat. The actual cycle of a four-stage

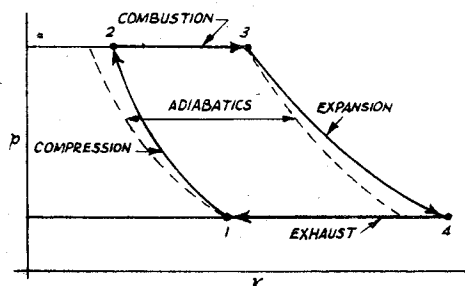


Fig. 1. Joule cycle

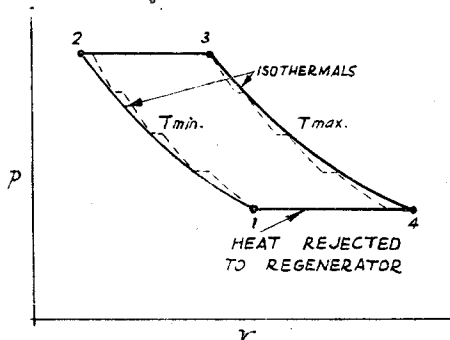


Fig. 3. Ericsson cycle

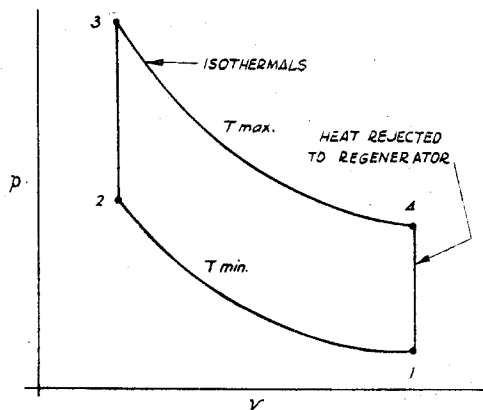


Fig. 2. Stirling cycle

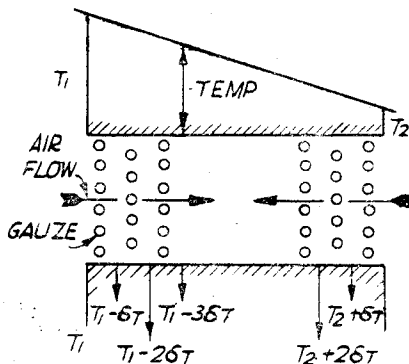


Fig. 4. Stirling regenerator

$T_{max.} - T_{min.}$  where  $T_{max.}$  is the maximum absolute temperature and  $T_{min.}$  the minimum temperature.

It should be observed that these temperatures are not dependent on the compression ratio. This

machine is shown dotted in Fig. 3, although this approaches the ideal cycle shown in black, yet fuel economy has been bought at the expense of heavy capital and maintenance charges.

During the constant pressure operations of the Ericsson cycle, or the constant volume operations

of the Stirling, heat is stored in or given up by a regenerator (Fig. 4). The purpose of this brilliant device of the Rev. Robert Stirling (1817) is evidently not appreciated by B.C.J., since he recommended its replacement by a plain cylindrical drum.

The "perforated box of wire entanglement" performs the office of regenerator and displacer.

The dimensions and thermal properties of the regenerator enable it to follow rapid changes of temperature, so that after air at the maximum temperature has flowed over the first layer of wire or gauze its temperature will have fallen by an element  $\delta T$ . The second layer will remove another element, and so on until the air finally

leaves the regenerator at the minimum temperature. On reversing the flow this graduated method of storing heat will return the air to its maximum temperature.

In the ideal Stirling and Ericsson cycles, therefore, heat is transferred to or from an outside source only during the isothermal operations. This was not realised in actual engines which were purported to operate on these cycles and, together with the poor thermal properties of air, were responsible for the

low efficiency of hot-air engines.

According to B.C.J., the Heinrici engine is the most efficient hot-air engine so far devised by man. Although the engine has certain com-

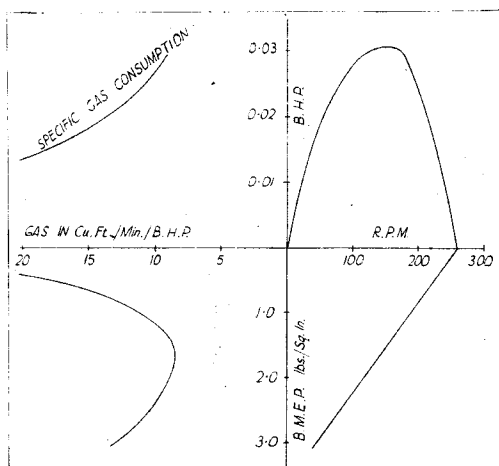


Fig. 5. Characteristic diagram

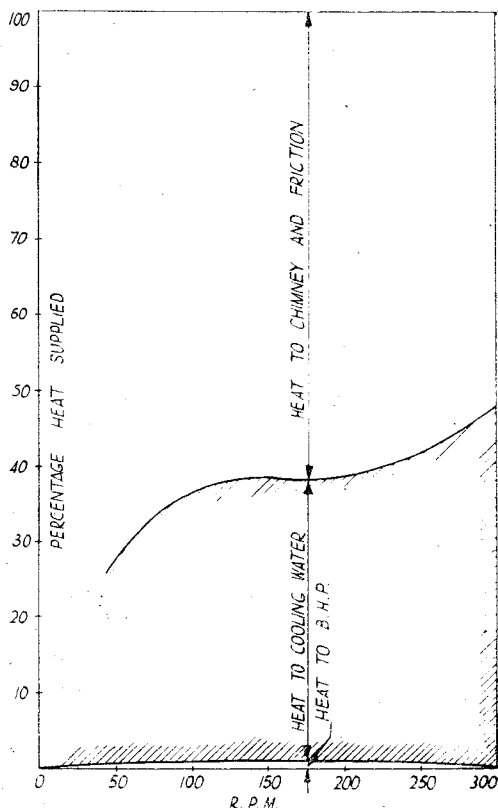


Fig. 6. Heat balance

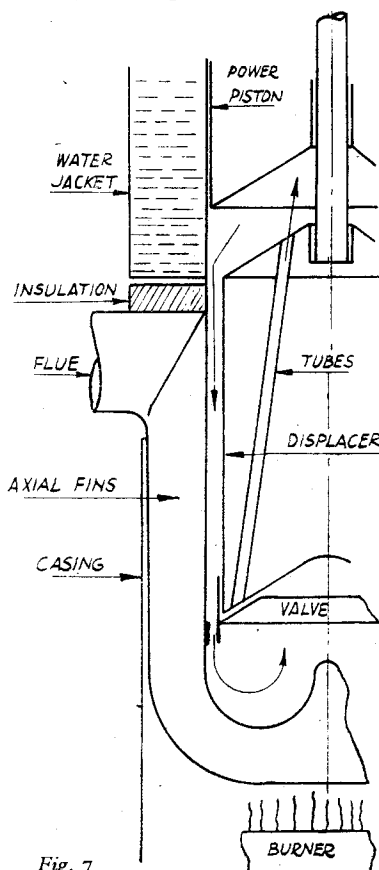


Fig. 7

mendable features, principally the removal of hot and cold sections, it has no regenerator. The air, in being driven continually backwards and forwards over hot and cold surfaces, causes valuable high-grade heat to by-pass the working cylinder. This transmission of heat is accelerated by the high velocity at which the air flows through the clearance around the displacer. High velocity flow through small ports is also objectionable because of the pressure drop required to overcome fluid friction.

The pressure is required to move the piston, not the air, so provide short ports of ample area.

The data, which were employed for the construction of the characteristic diagram (Fig. 5) and the heat balance (Fig. 6), were obtained from a Heinrich engine,  $3\frac{1}{8}$  in. bore by  $2\frac{1}{4}$  in. stroke, fired by a triple bunsen burner.

The maximum brake thermal efficiency recorded was 1 per cent. and the highest b.e.m.p. 2.8 lb. per sq. in. at 70 r.p.m. Obviously, tremendous improvements will have to be made before this engine could compete with the poorest of internal combustion engines.

With internal combustion the working fluid may momentarily attain flame temperature.

With external combustion this is never possible. Even with a moderate temperature applied to the displacer cylinder of the Heinrich engine, over 60 per cent. of the heat is lost in the flue gas. This indicates that the cylinder is deficient as a heat transmitting medium.

Improvement would be obtained by finning the cylinder and encasing it so that the hot gases are compelled to traverse the entire length of the cylinder wall in opposition to the cold air which is being driven downwards from the power cylinder. A further improvement could be effected by running tubes through the displacer piston,

making the ends of this piston conical and fitting a light hollow valve at its base (see Fig. 7).

With this arrangement, when the power piston is on the bottom dead centre, the displacer is moving rapidly upwards. This motion, combined with the conical contour of the piston, will drive the cold air down the cylinder wall, thereby producing contra-flow heating of the air. Inertia will cause the valve to open and allow the hot air, which has been swept upward by the contoured base of the cylinder, to pass into the power cylinder without having to traverse a cold surface.

The hot air will be in the region of the piston-rod and cold air on the cylinder-wall. Now, since air is a poor conductor of heat, this attempt at stratification should reduce the heat loss to the cooling water. As a further precaution, the displacer cylinder should be attached to the power cylinder through the medium of an insulating ring.

On the return stroke of the displacer hot air will be driven upwards through the annulus, and carry the cooler air in front of it to meet the air which is being driven downwards towards the cylinder wall by the power piston.

The misfortune is that a certain amount of valuable high-grade heat must be lost in this way to produce a partial vacuum, and without the vacuum the engine would be single-acting.

From the previous observations, it would appear that there can be little future for hot-air engines of the old type, regardless of their simplicity or the development in heat-resisting metals.

With hot-air engines high thermal efficiency can be obtained only at the expense of stage expansion, with all the complication of heaters and coolers. If we are prepared to go to this expense why not use steam plant or internal combustion engines with exhaust turbines?

## “L.B.S.C.”

(Continued from page 177)

as there is a great stress on these bearings. Chuck the rod, face, centre, and drill a  $\frac{1}{8}$ -in. pilot-hole about  $\frac{1}{8}$  in. deep; follow up with a 27/64-in. drill. Turn down  $\frac{1}{8}$  in. of the outside to  $\frac{1}{16}$  in. diameter, then further reduce 13/32 in. length to a squeeze fit in the holes in the bosses of the rods. After what I've said about squeeze-fits for wheel-seats and crank-axle spigots, I fancy there's no need to go over the whole rigmarole again! Part off to leave a head a full  $\frac{1}{16}$  in. in thickness. Ditto repeat for four or six bushes, as the case may be; then press them into the rods by aid of your bench vice. Drill a  $\frac{1}{16}$ -in. oil-hole in the top of each oil-box, and counterbore it 5/32 in., as shown by the dotted lines. Finally, put a  $\frac{1}{16}$ -in. parallel reamer through the bushes in the driving-bosses, and a  $\frac{1}{16}$ -in. clearing drill (say 11 $\frac{1}{2}$  mm. if you have one, or 29/64 in. if you haven't) through the others. The clearance allowed on a full-sized engine is  $\frac{1}{16}$  in. Put the coupling-rods on the wheels, fit the little flanged collars, pin them, and if Bob wasn't your uncle before, he should be,

this time! The wheels should turn freely, the coupling-rods working without any sign of binding or slackness at any part of the revolution.

### The First “B.R.” Engine

Several readers have suggested, half in jest and half in earnest, that your humble servant should give a “condensed” description plus the principal drawings, of a  $3\frac{1}{2}$ -in. gauge edition of what I consider the ideal express passenger locomotive for the principal main lines of the nationalised “British Railways.” Well, I can't do any more at present, because in fulfilment of promise not to let the  $3\frac{1}{2}$ -in. gauge enthusiasts' tools go rusty, I am trying to get out the needful for a L.M.S. class 5 (Black Stanier) in that size; but I already have an engine which would do fine for the B.R., in the person of “Tugboat Annie.” With a tractive effort of nearly 50,000 lb. and a top speed of 140 m.p.h. with a 500-ton load, she would literally be “the answer to the driver's prayer”!

# Editor's Correspondence

## Noise Suppression

DEAR SIR,—I have just taken up residence in S.W. London in a first-floor flat.

I wonder whether any other reader has, even though living in a flat, managed to carry on model making, with the inevitable light sawing, filing and noise made by a  $\frac{1}{4}$ -h.p. motor driving a  $3\frac{1}{2}$ -in. lathe and drill.

If anyone could help to solve the noise and vibration problem I would be deeply grateful.

Yours faithfully,

London, S.W.

A. W. FEASEY.

## Food for Thought and Action

DEAR SIR,—It was with some interest that I read the article on "Hot-air Engines" by B.C.J. in a recent issue in which he revived some of the history surrounding this type of engine, together with some of his own experimental work. After the pioneer period of 1699 (Amouton—France) to 1852, when Ericsson's "caloric engines" were at work in a factory in New York, came the inventions of Napier, Rankine, Bickford and others in the 1860's. Much attention was being paid to solving some of the problems necessary to make the "hot"-air engine a commercial success. It would appear that the theory of the heat cycle applied to the hot-air engine may be superior to that of the steam engine and boiler, but in spite of the many claims of inventors, practice has proved the opposite to be the fact. Maybe, largely because the state of the metallurgical arts, in the period under review, did not provide a metal, or alloy capable of withstanding the arduous duties demanded, where high temperatures were involved. If, as is reported, a firm abroad have solved some of the problems of the hot-air engine in a practical fashion, then it is possible we may witness a revival of this form of power unit. Whether the new success claimed is due to the availability of new metals capable of standing up to high temperatures, or if some of the success claimed is due to a method of working on a lower temperature range, possibly with the aid of the principles underlying the use of the "heat pump," or both, I do not know, but I do think there are possibilities of success in a combination of these modern developments, bringing the hot-air engine forward as a means of successfully supplying some of the needs of the small power user.

So far, so good, but it may be pertinent to stress, however, the point, that in my opinion, we shall also witness a revival of other old forms of power units not requiring fuel, e.g., windmills, waterwheels, etc., also methods of applying animal power, for example, the "horsemill" or "race." All these latter forms of small power generation are very old and well tried; the popular use of them declined in face of the competition based on convenience offered by cheap fuel in the form of coal and oil, etc. The era of these fuels in their "cheapness" and plentiful supply would appear, so far as our own country is concerned, to have ended.

Coal, potentially plentiful at home, in all its forms, has, as we well know, increased very considerably in price. This fact, coupled with the necessity, for economic reasons, of exporting as much coal as possible abroad, and the control of uses and rationing of coal fuels at home, by the Government, who now have monopoly, all point to a long period of possible further increases in coal prices, together with controls, until equilibrium is again restored, in the way of supply and demand.

The position regarding oil (and its derivatives) as a fuel is, I think, still less satisfactory; primarily because it is not home produced. We are well aware of the controls surrounding the use of this fuel; the world supply and demand for oil presents many problems of which I need not deal with here. Sufficient, then, is the reason why circumstances at home may provide the incentive to revive the older sources of power, even lacking, as they do, the convenience for instant use we are at present accustomed to, but in the national interest, necessary.

Much has been written and talked of what "atomic" energy may do; I think, too little is known yet about this new form of energy to offer more than guesses as to when it may be available; the best estimate is, many years may elapse before power derived from "atomic" energy is "on tap" for the small user. Also the possibility of unforeseen difficulties in its application should not be overlooked.

I have, I think, outlined some of the reasons why we may turn to older forms of power production; applying modern methods of construction, such as anti-friction bearings, light alloys, and so on. First, then, in possible revivals, I would place the "windmill," with accessories such as electric generator and storage battery, as likely to provide the widest application with the least complication for a small user of power. On the farm, obviously, animal power could be revived to operate stationary machinery; in certain districts the power of falling water has possibilities. We may yet find the force of "tides" harnessed in greater use. Other forms of "home produced" fuel could be developed, e.g., power alcohol, if the encumbrance of excise restrictions could be overcome. We have heard also of the possibilities thrown open by modern methods of producing oxygen, in bulk, cheaply; also the possibility of favourable developments on the lines of the before-mentioned "heat pump."

Sufficient, I think, has been written, calling attention to the many avenues available to the model and experimental engineer to develop and improve on old methods of power production, on established lines or in some of the newer directions; any and all of which, examined again and again to provide for ever-growing demands of the community at large, for more and more power, now a necessity for our present standard of life to be maintained.

Not a few of the foremost industrialists, present and past, started their careers as experimenters in home workshops; circumstances of our own time may offer new roads to fame!

Yours faithfully,

Bradford.

W. D. HOLLINGS.